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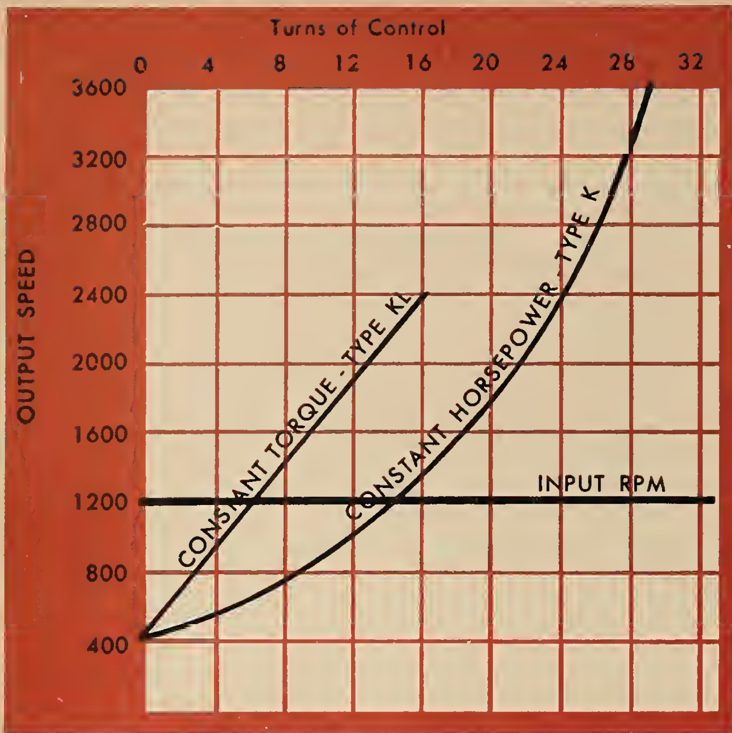


CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

ANNOUNCED late in 1954, the new Cleveland Speed Variator met instant, enthusiastic acceptance. Engineers and designers of industrial equipment already have put thousands of units into use on such varied equipment as cigarette making machines, textile machinery, metalworking machinery, pharmaceutical equipment, transfer tables, conveyors and experimental and testing equipment of many types.

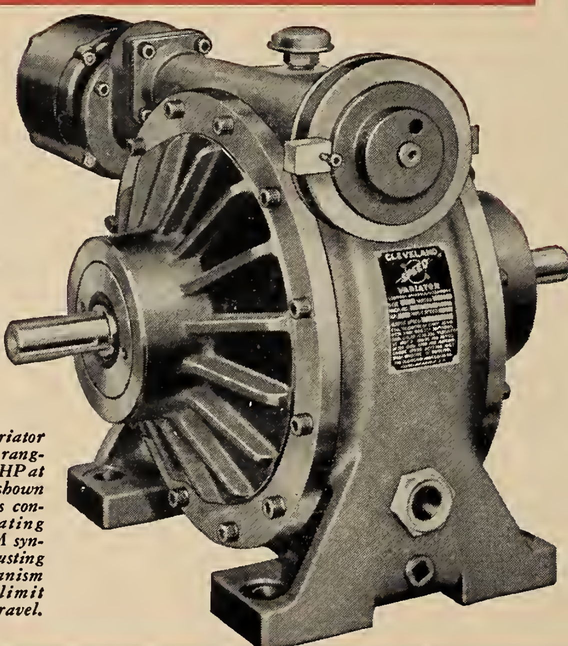
Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.
2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.
3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.
4. Speeds infinitely variable over entire range of adjustment.
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.
6. Long life and minimum maintenance due to absence of belts or complicated linkages.
7. Ample bearing support for overhung pulleys on both input and output shafts.

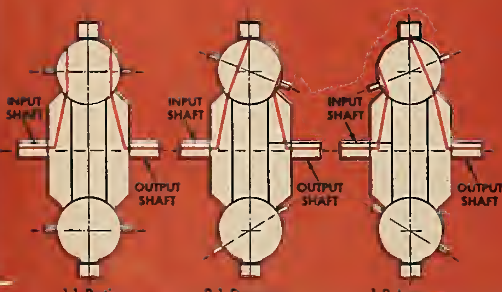
Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

Typical speed regulation curves for the Types K and KL Variators. Type KL offers a linear speed regulating pattern, often an advantage in automatic control applications. Output speed regulation of the Type K Variator follows a geometric progression pattern. Starting at the minimum output speed, each turn of the speed regulating wheel produces a fixed percentage increase in output shaft speed.



The Cleveland Speed Variator is available in 18 models ranging from fractional to 16 HP at 1750 input RPM. Unit shown at right, used in process control, has speed regulating worm driven by 75 RPM synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (diagram, right, shows cutaway Variator with hand regulating wheel).

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MEET THE AUTHORS

F. T. Matthias, director of engineering and construction, Aluminum Company of Canada, Limited, Montreal *(Planning and Construction of the Chute-des-Passes Hydroelectric Power Project).*

Mr. Matthias received his B.S. degree in civil engineering from the University of Wisconsin in 1931, and an M.S. degree in 1933. From 1931 to 1935 Mr. Matthias was an instructor at that university. He worked with the Tennessee Valley Authority for four years and later with Johnson Construction Company and the Dravo Corporation. In 1941 Mr. Matthias joined the U.S. military service and after five years in the forces worked in Brazil on hydroelectric design and construction. He became assistant manager of Alcan's B.C. Project in 1952 and was appointed chief engineer in 1956. In 1957 he was promoted to his present position.

F. J. Travers, M.E.I.C., senior project engineer, H. G. Acres and Company Limited, Niagara Falls, Ont. *(Planning and Construction of the Chute-des-Passes Hydroelectric Power Project).*

Mr. Travers received his B.A.Sc. in civil engineering in 1944 and after graduation joined McColl-Frontenac Oil Company Limited in Montreal. He worked for the Hydro-Electric Power Commission of Ontario from 1947 to 1955 co-ordinating the construction of generating stations and the activities of the joint power development in Cornwall. In 1955 he became a senior project engineer for H. G. Acres and Company.

J. W. L. Duncan, administrative representative for the installation of all electrical and mechanical equipment, Aluminum Company of Canada, Limited, Chute-des-Passes, Que. *(Planning and Construction of the Chute-des-Passes Hydroelectric Power Project).*

Mr. Duncan obtained an M.A.Sc. degree from the University of Toronto in 1950 and joined the Aluminum Company of Canada, Limited the same year. Working on the Chute-des-Passes project, Mr. Duncan was involved in the initial hydraulic and power studies and later in equipment specifications.

C. L. Merrill, district administrator, Fort Smith, Department of Northern Affairs and National Resources *(The New Aklavik—Search for the Site).*

Mr. Merrill studied geology at Western University and continued with post-graduate studies in geography from 1945 to 1950. He participated in the sea-borne expeditions, "NAUJA" and "CANCOLIM". As project manager from 1954 to 1956 Mr. Merrill was in charge of siting and development work at the New Aklavik.

J. A. Pihlainen, JR.E.I.C., Northern Building Section, Division of Building Research, National Research Council, Ottawa *(The New Aklavik—Search for the Site).*

Mr. Pihlainen received a B.Eng. from McGill University in 1950 and his M.S. in civil engineering from Purdue University in 1952. For the past ten field seasons he has been carrying out research for the N.R.C. on permafrost, engineering site investigations and building foundations, principally in the Mackenzie River district of the N.W.T.

Robert F. Legget, M.E.I.C., director, Division of Building Research, National Research Council of Canada, Ottawa *(The New Aklavik—Search for the Site).*

Mr. Legget graduated from the University of Liverpool, England in 1925 and received the degree of Master of Engineering from the same institution in 1927. He came to Canada in 1929 and was engaged in heavy construction engineering until 1936 when he entered the educational field. Mr. Legget was on the Queen's University staff for two years and then on the University of Toronto faculty until 1947 when he was appointed by the National Research Council to head the new Division of Building Research.

G. L. Tiley, application engineer, Mining, Petroleum and Chemical Division, Canadian Westinghouse Company Limited *(Industrial Uses for an Auxiliary Low Frequency Supply).*

Mr. Tiley was born and educated in South Africa and received his B.Sc. in electrical engineering from the University of Witwatersrand in 1941. In 1946 he was awarded a B.Sc. in Mechanical engineering from the same university. From 1942-1945 he served as a radar officer with the Royal Navy. He was employed as an engineer on the Gold Mines of Witwatersrand before coming to Canada to his present position.

E. Oldfield, application engineer, Mining, Petroleum and Chemical Division, Canadian Westinghouse Company Limited *(Industrial Uses for an Auxiliary Low Frequency Supply).*

Mr. Oldfield was educated in Manchester, England and received the higher National Certificate (Electrical) from Manchester College of Technology in 1943. He was apprenticed at Metropolitan-Vickers Electric Company Limited during the war, working in the mine hoist electrics division.

K. A. Henry, JR.E.I.C., river control engineer, The Hydro-Electric Power Commission of Ontario *(River Control in the International Rapids Section — St. Lawrence Power Project).*

Mr. Henry graduated from the University of Alberta in 1948 with a B.Sc. in civil engineering. He was supervisor of hydraulic operations during construction at Rolphton, Ontario, then spent five years in the Ontario Hydro's hydraulic model laboratory at Islington and the University of Toronto, constructing and testing models of the Niagara and St. Lawrence Hydro-Electric projects.

J. A. Reid, JR.E.I.C., manager of motor sales, motor and Generator Division, Canadian Westinghouse Company Limited, Hamilton *(Voluntary Standards—Vital to Progress).*

Mr. Reid graduated in electrical engineering from the University of Manitoba in 1949 and joined Canadian Westinghouse Company Limited the same year on the graduate student program.

COVER PICTURE

We are indebted to Aluminum Company of Canada for this striking view of the draft tube manifold at Chutes-des Passes.

General view of power development looking upstream

Extensive Dominion Bridge Equipment Now In Operation at the Beaumont Power Project

The Shawinigan Water and Power Company's hydro-electric developments on the St. Maurice River in the province of Quebec, designed and constructed by The Shawinigan Engineering Company, Limited are now providing a power capacity in excess of two million horsepower. Seven sites have been developed and the Beaumont power project is the latest. Three more usable sites remain.

The Beaumont development is located ten miles above La Tuque and provides 330,000 horsepower from six 55,000 horsepower Francis turbines.

The development included numerous major projects: construction of access roads; erecting construction plant and housing; excavating over 11,000,000 tons of earth and rock and building and equipping the dam and power station; erecting a 90-mile transmission line; relocating a 10-mile stretch of railway; building two railway bridges; and driving a 700-foot railway tunnel.

WINNIPEG — CITY OF FORTS

1960 CONVENTION CENTRE

Lower Fort Garry, now one of Winnipeg's major tourist attractions, was once the seat of government. Almost all of what now is Canada was ruled from this fort. It was also, for a while, headquarters of the Hudson's Bay Company. A corner of the old fort is shown below.

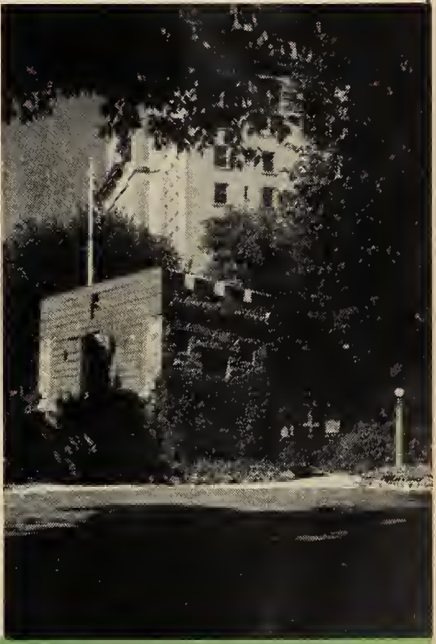
Lower Fort Garry, built 1832, is the only stone fort of the fur trade regime still intact anywhere in North America. It is now a museum and home of the Winnipeg Motor Country Club. Superb food and golf have replaced beaver tail and pemmican, and the rough games of the Indians and fur traders.

The original Upper Fort Garry was built in 1821, was reconstructed and enlarged in 1839, and finally dismantled in 1882. The North Gate, below, is all that remains of the proud old fort which was occupied by Louis Riel's forces and later by Wolseley's Red River Settlement volunteers.

Three famous forts once stood at the forks of the Red and Assiniboine Rivers: Fort Rouge, the first structure built on the site of the present city of Winnipeg; Fort Gibraltar of the North West Company, and Upper Fort Garry of the Hudson's Bay Company.

Within their thick walls, as well as at Lower Fort Garry (18 miles north of Winnipeg), members of the governing bodies made the policies and took the actions which decided the future not only of the West but of Canada as a whole.

The old forts and their purpose have long been gone but the City of Winnipeg remains as a bastion of economic and cultural development.



PLAN NOW TO ATTEND the 74th ANNUAL MEETING

Royal Alexandra Hotel — MAY 24-27, 1960 - WINNIPEG

A MESSAGE

FROM

THE PRESIDENT

It is a pleasure and a privilege to announce that, effective with this issue, The Engineering Institute of Canada will send *The Engineering Journal* each month to over 32,000 engineers in this country.

For many months, the Council of the Institute considered ways and means of obtaining wider dissemination of the technical articles and news items which *The Engineering Journal* contains, to ensure the maximum effectiveness of the publication as an essential service to Canadian engineers.

The Engineering Journal will be sent without charge to over 32,000 engineers in Canada, and to members of the Institute outside the country. All other subscribers will be required to pay the regular subscription rate.

It is the Institute's aim to make every issue topical and highly informative. An even balance between reading and advertising content will be maintained.

Obviously, to ensure the success of this venture, we must have the full co-operation of the recipients of the publication. We hope that they will keep the Institute informed of their changes in address and occupation so that the mailing lists may be kept up-to-date.

We are always happy to have comments and suggestions from our readers for further improvements.

J. J. Hanna

J. J. HANNA, M.E.I.C.
President

THE ENGINEERING INSTITUTE
OF CANADA

PLANNING AND CONSTRUCTION OF THE CHUTE-DES-PASSES HYDROELECTRIC POWER PROJECT

F. T. Matthias, *Director of Engineering and Construction Aluminum Company of Canada Limited, Montreal, Que.*

F. J. Travers, M.E.I.C., *Senior Project Engineer at Chute-des-Passes, for H. G. Acres & Company Limited Consulting Engineers, Niagara Falls, Ont.*

J. W. L. Duncan, *Electrical Engineer Aluminum Company of Canada Limited, Isle Maligne, Que.*

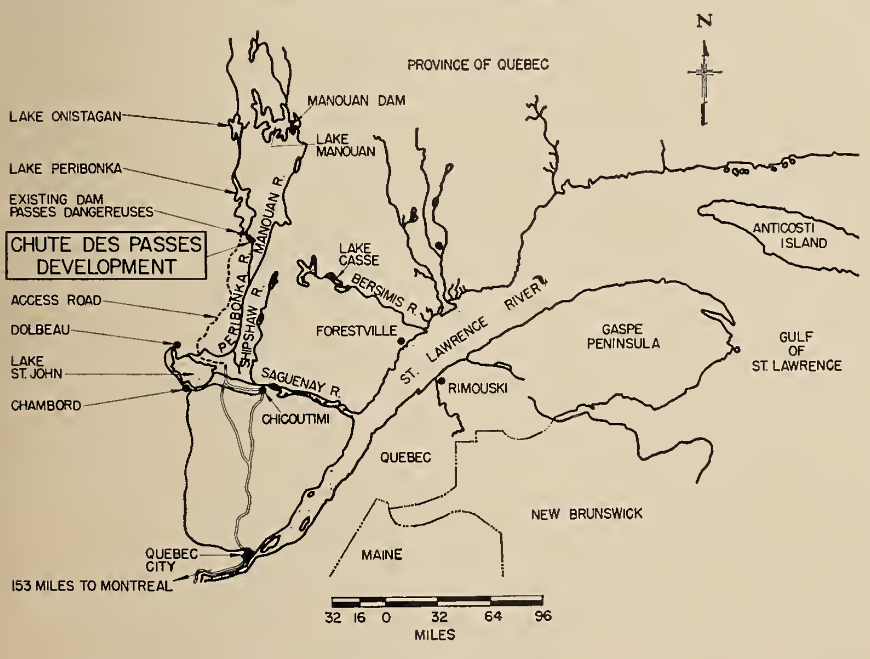
THE SAGUENAY and Peribonka Rivers are famous in the annals of early Canadian exploration and fur trade, this course being a main route from the St. Lawrence River to Lake Mistassini and thence to James Bay. This district is known generally as the Saguenay area and is shown in Fig. 1.

The power potential in the Saguenay has been recognized for a long time and the first grant for a power development was issued in 1900. After a series of surveys by various interested parties over the years, actual construction of the Isle Maligne development was started in 1922 and ultimately grew to an installed capacity of 540,000 h.p. Subsequent projects on the Saguenay system were the 300,000 h.p. Chute-a-Caron development completed in 1931, the Shipshaw 1,200,000 h.p. development completed in 1942, the Chute-du-Diable development completed in 1952 and the Chute-à-la-Savane development completed in 1953. In 1941 the Aluminum Company of Canada, Limited, completed construction of the Lake Manouan Storage Dam and in 1943 the Passes Dangereuse Dam was put into operation. The waters impounded in these two reservoirs, together with that stored in the older reservoir, Lake St. John, effect the required hydraulic regulation for the existing power system of some 2,600,000 h.p. of installed capacity. The system is operated jointly by the Aluminum Company of Canada, Limited and the Saguenay Power Company, Limited.

While no physical facilities were built into the Passes Dangereuse Dam towards utilization of the head developed by the dam and the steep fall of the Peribonka River through a 6½-mile reach downstream, the power potential was recognized and planning and studies were carried on. In 1955, as load growths indicated need for additional power, a comprehensive preliminary engineering study of the project was made and a report issued in January, 1956. Detailed studies continued and by middle 1956 the general design had been established.

The drainage area above the Passes Dangereuses Dam is 4,787 square miles, and the Lake Manouan Dam controls storage from an additional 1,920 square miles. Unfortunately, however, the natural outlet of Lake Manouan discharges into the Peribonka River some thirty miles downstream from the Chutes-des-Passes development. To utilize the Lake Man-

Fig. 1. Location of development.



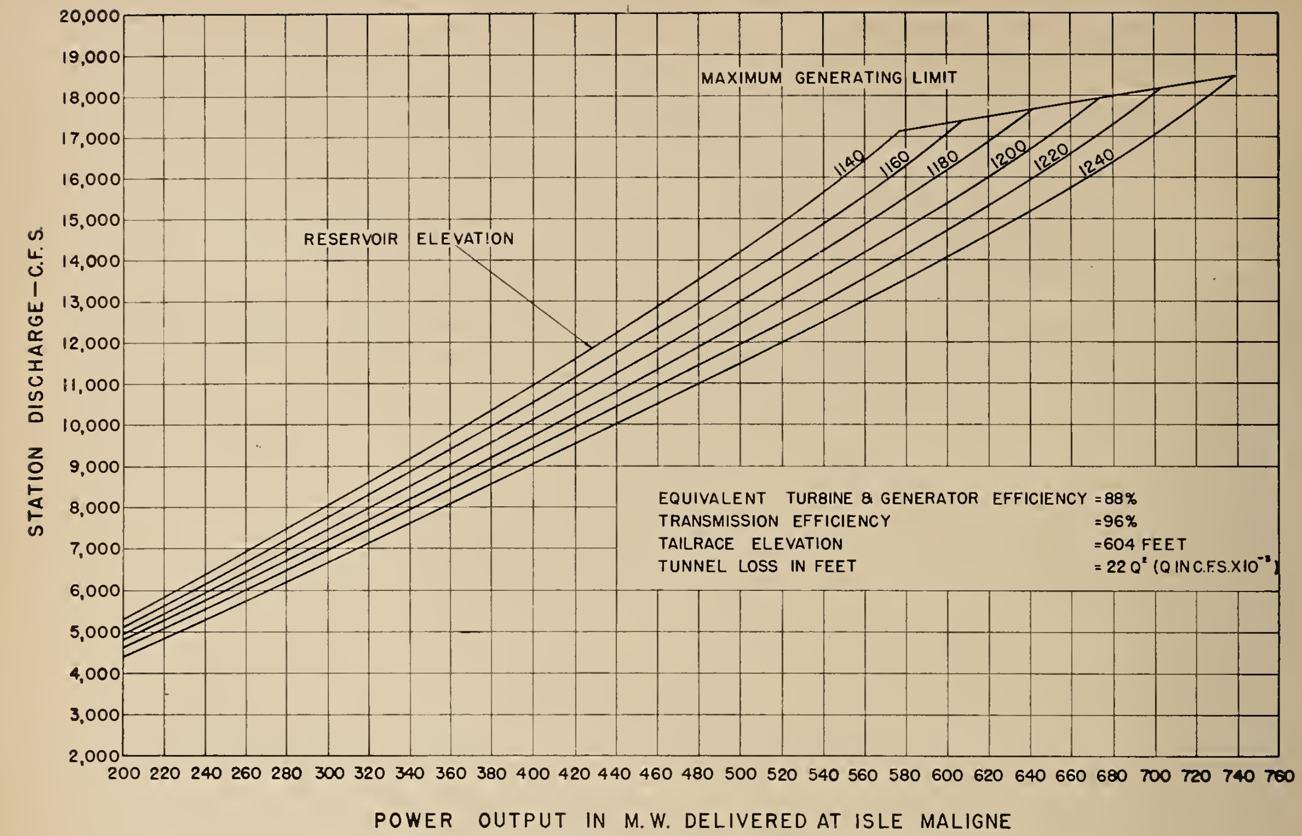


Fig. 2. Power at Isle Maligne v. station discharge at Chute-des-Passes.

ouan water through Chutes-des-Passes Powerhouse requires a controlled outlet and channel to the reservoir above Passes Dangereuse Dam. The plan to accomplish this is to build a concrete control structure near the western end of Lake Manouan and a channel about 2-miles long into the Bonnard River which is part of the Passes Dangereuse drainage area. Studies indicated that with such a diversion the Chute-des-Passes Project would increase the "Firm Generation" of the Saguenay Power System by some 675,000 h.p. The studies further indicated that a station would be required having a nominal capacity of 1,000,000 h.p. with the reservoir near the top elevation of 1,240 ft. and a capacity of 800,000 h.p. at an elevation of 1,140 ft. With such an installation the installed capacity of the Saguenay Power System would be about 3,600,000 h.p.

General Design

Consideration of topography and geology indicated that an underground development would be the most practicable and economical. Several arrangements of intake tunnel, powerhouse and discharge tunnel were considered during the early stages of design. For an underground station the powerhouse must be under enough good rock cover to be safe under the hydraulic and rock pressures existing. The elevation of the powerhouse had to be established relative to the tailrace discharge, so factors determining location involved tunnel location, position of powerhouse along the tunnel and the rock topography.

Core drill sub-surface investigations indicated that the rock was generally sound. The drilling confirmed the presence of a short but major fault section between the powerhouse and the reservoir that had been identified as a probability from surface geological exploration. Careful attention during core drilling was paid to the bedding planes and joint systems of the rock as well as to the general character of the material. As a result of these investigations the powerhouse was changed 90° in orientation to improve the strength of the side walls. In its revised location, the longitudinal line of the powerhoure is approximately at right angles to the strike of the bedding planes of the rock. This orientation minimizes the possibility that rock might slide out of the side walls which could weaken the haunch that supports the concrete arch of the powerhouse.

Core drilling information also confirmed surface indications of extensive faults along the east side of the Peribonka River, originally selected as the line for the tailrace tunnel. This poor rock was certain to cause serious excavation problems and surface geological indications were carefully studied to determine likely alternate routes. The more favourable route followed crossed under the Peribonka River below the powerhouse and then back into the river from the west side. Core drilling done along this route confirmed its desirability.

The intake structure will take water from the Passes Dangereuse reservoir adjacent to the dam on the left bank. This intake will provide for 100 ft. drawdown from elevation 1240 to 1140 in the reservoir. The tailrace elevation is approximately at elevation 604 ft. Because of the depth and size of gates required and the large drawdown, the intake gate structure presented problems in design almost without precedent. The bottom of the intake gates is about 160 ft. below the maximum reservoir surface.

Description and Layout

Starting at the intake, water will be taken from the Passes Dangereuse Reservoir into an intake tunnel leading to the intake structure. Thence the water is carried in a concrete-lined supply tunnel, 31,000 ft. long, to a penstock manifold. From this point the water is lead to each unit through steel-lined penstocks and is then discharged from the units into the draft tube manifold. The water is then carried in an unlined discharge tunnel some 9100 ft. in length leading back to the Peribonka River.

Power will be generated at a nominal voltage of 14.4 kv., transformed to 385 kv. in a surface switching station and transmitted to Isle Maligne some 90 miles distant. The original power studies were based upon curves such as those shown on Fig. 2 but these curves will require modification subsequent to the completion of the station when the actual hydraulic losses and equipment efficiencies will be known.

Construction at Chute-des-Passes was begun in the summer of 1956 and the initial power output is expected to be in September, 1959.

Intake

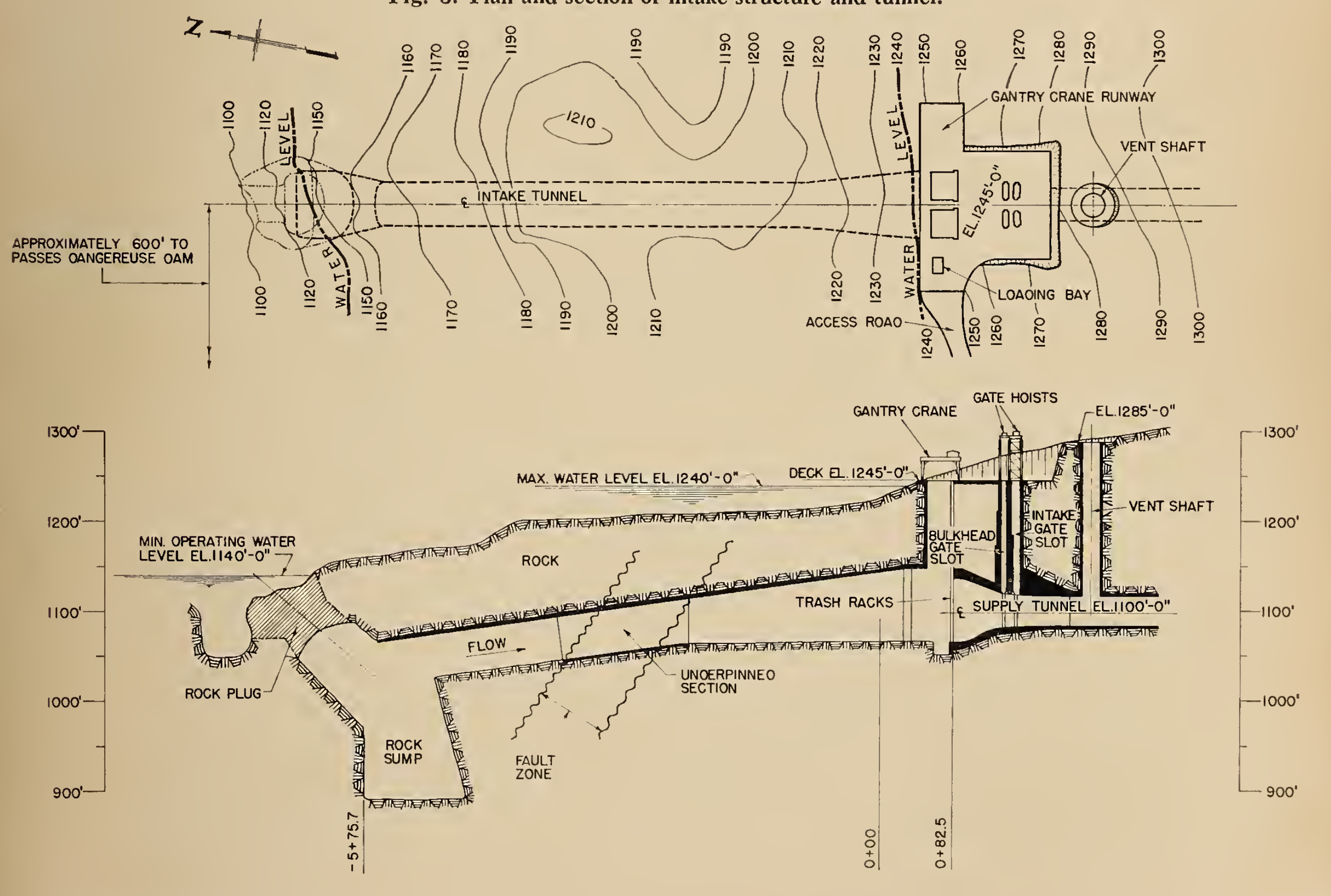
Referring to Fig. 3, the intake as a whole consists of a tunnel intake at the bottom of the reservoir, an intake tunnel and a reinforced concrete structure incorporating trash racks, one bulkhead gate, two intake gates and a vent shaft.

Ingress of water to the intake and other workings downstream was blocked by a rock plug which was removed on 19th April, 1959. Removal of this plug was contingent on low water levels in the reservoir and optimum conditions for the operation did occur just before the Spring breakup which takes place sometime between 1st April and 10th May of each year. Models were built to determine the shape and location of the inlet from the bottom of the reservoir and extensive tests were carried out utilizing different shapes to arrive at an optimum design. Associated with this design, other studies were carried out to determine the shape and size of the sump required to catch the rock from the plug when it was blasted. After numerous experiments utilizing various combinations of plug and sump shapes, it was possible to determine the behaviour of falling rock so that a minimum quantity of rock would be carried down the intake tunnel by the inrush of water.

Water will be led to the intake structure by means of a partially-lined intake tunnel about 600 ft. long. The lining consists essentially of a concrete arch which will offer permanent support to the rock above the tunnel. One of the two major faults encountered in the underground work on the project was in this tunnel upstream from the intake and the arch in the area is underpinned with reinforced concrete. Further protection of the rock is afforded by a reinforced concrete floor extending the full length of the faulted area. The intake tunnel is horseshoe shaped in cross-section and over its greater length is 50-ft. wide and about 50-ft. high. At a point approximately 300 ft. upstream from the trash racks the floor of the tunnel changes grade and the height of the tunnel begins to increase as it approaches the intake structure. Referring to the plan view, the tunnel begins to widen 176 ft. upstream from the trash racks and reaches a maximum width of 70 ft. and is about 80 ft. high as it enters the trash rack shaft. The form and extent of the transition were determined from model studies performed to establish an arrangement giving an even distribution of flow across the trash racks. Velocities through the intake tunnel are in the order of 9 or 10 ft. per second under maximum flow conditions. With all five units operating the average net velocity of the water between the trash rack bars will be approximately 6 ft. per second which will uniformly accelerate to a velocity of 18.6 ft. per second in the supply tunnel.

The intake structure is located in open rock cut about 80-ft. wide, 110-ft. long and about 215-ft. deep. The

Fig. 3. Plan and section of intake structure and tunnel.



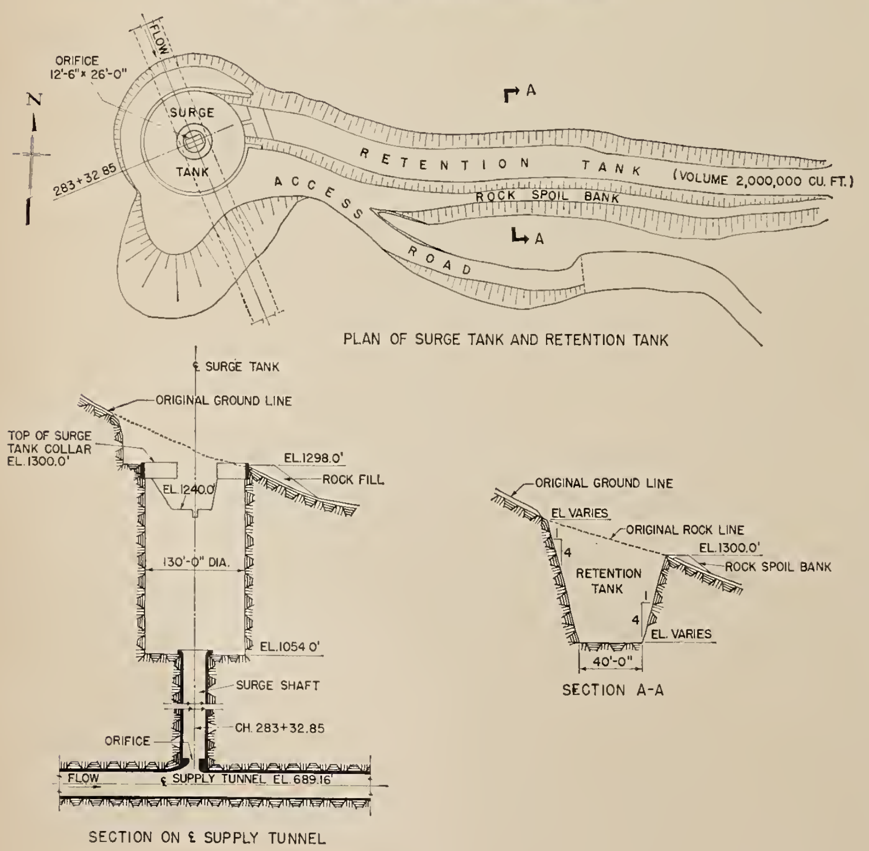
flow of water approaching the structure is divided by a central pier which extends 18 ft. upstream into the intake tunnel, thus providing additional support for the wide tunnel arch span at this location. The central pier terminates about 60 ft. downstream from the intake gates. Essentially the basic requirements for an intake of this type is to have a streamlined intake tube which will accelerate the water from the trash racks to the junction of the intake with the supply tunnel, keeping hydraulic losses to a minimum. This requires a properly designed transition. The entire transition from the trash racks to the beginning of the supply tunnel is 125 ft. in length.

The trash racks are made up of 6-in. by ½-in. bars, with a spacing of 5½ in. The bars are fabricated into panels 33 ft.-10 in. wide and 8 ft.-10 in. high with eight such panels comprising a whole trash rack. The racks are designed for a differential head of 35-ft. within normal design stress limits. A deflector will be provided to rest on the top panel of each opening to prevent the accumulation of trash on the top of the racks. The trash racks will be serviced by a gantry crane operating over the trash rack opening. Cleaning of the racks will be accomplished by utilizing a clam bucket operated by a gantry crane to remove trash accumulated in the sump located immediately upstream from the racks.

Guides for one bulkhead gate are provided in each water passage and the gate can be lowered into either passage by a hoist located on a steel superstructure which also incorporates the fixed hoists for the two intake gates. The bulkhead gate is a sliding type of gate with downstream seals and can be lowered only under static water conditions. Under emergency conditions with one intake gate lowered and the bulkhead gate positioned in the other water passage, access can be gained to the embedded parts and sealing faces of the second intake gate. The bulkhead gate is 40 ft.-3 in. high by 19 ft.-6 in. wide.

The two intake gates are of the fixed roller type with upstream seals. The gates are 16 ft.-10 in. centre to centre of the rollers and 38 ft.-5½ in. high and are operated by fixed hoists located on the deck superstructure. The lowering rate of the gates is one foot per minute, a limitation imposed by hydraulic considerations associated with surges in the supply tunnel. These gates can be lowered under full flow conditions should the need arise. During normal operating conditions, both gates will be stored just above the lintel of the gate opening and will be suspended by steel links pinned together.

Fig. 4. Surge tank and retention tank.



Supply Tunnel

The supply tunnel will be concrete-lined through its entire length and is a modified horseshoe shape in cross-section. This tunnel was driven from the three adits and five headings were in progress simultaneously. The finished tunnel will have a nominal diameter of 35 ft., or in other words the cross-section is equivalent to circular tunnel of this diameter. Actually the diameter of the top half tunnel is 34 ft.-7 in., the remaining equivalent area being made up by flattening the invert and extending the sides to meet the short radius fillets in the lower corners. This shape was mainly chosen for convenience of construction and afforded the contractor a relatively flat area to work from. The thickness of the concrete lining averages about 1 ft.-9 in. and the minimum distance allowed between the points of rock and the inside face of the concrete is 12 in. Where support was required in faulted areas, steel sets were employed. Any voids between the concrete lining and the rock will be filled with grout, and where rock support is necessary a program of consolidation grouting will be performed. Areas associated with water seepage will also be grouted to prevent undue external water pressure coming to bear on the lining in the event of the tunnel being dewatered. Manning's 'n' of 0.012 was used in hydraulic studies of the concrete-lined tunnel to estimate the losses therein.

Large pressure conduits excavated in rock rely on the overlying rock to provide resistance against bursting under pressure. The criterion adopted for the location of the Chute-des-Passes tunnel was to maintain at least 50% of the maximum head of water in feet, in rock cover. Actually the specific gravity of the rock encountered averaged about 2.7.

Surge Tank

Ideally, the surge tank should be located as close to the powerhouse as possible, but the topography dictated that it be placed some 2,800 ft. upstream from the penstock manifold. The general arrangement is shown in Fig. 4. The unlined tank, except for a concrete collar at the top, was constructed in sound bedrock and is 130-ft. in diameter and approximately 250-ft. deep. A 30-ft. diameter concrete-lined surge shaft leads vertically from the supply tunnel and enters the surge tank through a reinforced concrete annulus 6 ft. high which serves as a rock trap. A reinforced orifice is located at the bottom of the surge shaft just above the crown of the tunnel.

It has long been understood that regulation of flow at surge tanks could result in unstable oscillations in the surge tank if the areas were too small in relation to that of the conduits. To supply a constant load, turbines will pass more water when the level in the surge tank is low than when the level is high. This condition accentuates the potential surge and requires a careful study. As discussed later, the draft tube manifold acts as a surge tank for the discharge tunnel. Chute-des-Passes is therefore unique in that a surge shaft is required both upstream and downstream from the powerhouse. Stability limits for initial design were most easily obtained using "Routhe's" discriminate to determine the stable tank areas, as indicated in Fig. 5. However, as the hydraulic transients associated with this double surge tank development are quite complicated, the final diameter of 130 ft. for the upstream surge tank was adopted only after extensive analog computer studies, which examined in detail the regulating qualities of this tank.

The design condition of a full load rejection also required careful consideration. If the upstream surge tank diameter of 130 ft. had been kept uniform, the surge height on full load rejection could have reached elevation 1,342 ft., which would have caused serious over-pressures in the tunnel and other hydraulic equipment. This led to the provision of the retention tank to store the water overflowing from the surge tank following a full load rejection.

With five units operating and the Passes Dangereuse Reservoir at 1,240 ft., a maximum surge level of 1,290 ft. can be reached in the retention tank. One minute after full load rejection under these circumstances, the water level in the surge tank would rise to elevation 1,263 ft. with the water level in the retention tank gradually rising and attaining an equal and higher level two minutes after load rejection. The period of the surge from maximum to minimum elevation and back to maximum is about 18 minutes under this extreme condition.

With an operating level of 1,140 ft. at Passes Dangereuse, the maximum surge level in the surge tank will be 1,250 ft. after a full load rejection with no spillage into the retention tank. The period of oscillation in this case is about 10 minutes. Under this operating condition, if one unit were put back on the line with the transient elevation in the surge tank dropping, the worse point of load acceptance would result in an even lower drop in the surge level. To aid the operators in avoiding conditions such as this, a surge level indicator and recorder will be placed in the control room to ensure that load acceptance is made during a rise in the transient water level in the surge tank.

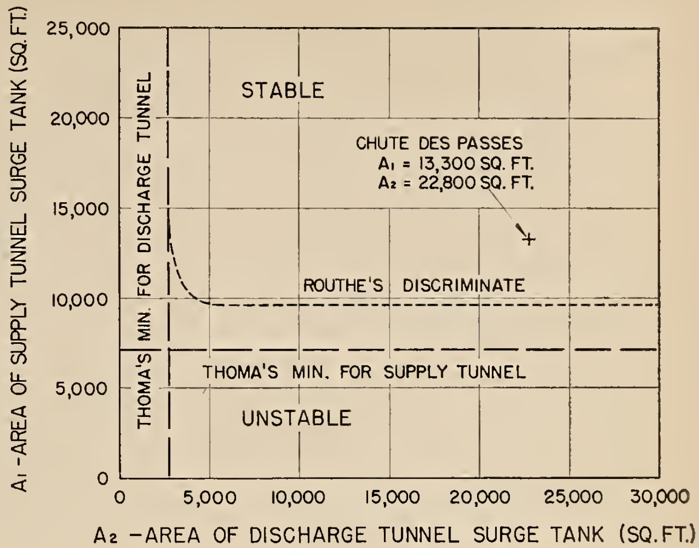


Fig. 5. Minimum areas for surge tank stability.

Penstocks

There are five steel-lined penstocks leading from the penstock manifold, each penstock serving one unit. They vary in length from 256 ft. to 394 ft. and are steel-lined throughout their entire length. Fig. 6 shows the general arrangement of the penstock manifold and the penstocks. The inside diameter of each penstock varies from 15 ft. at the upstream end to 11 ft. at the downstream end. The design of the turbine inlet dictated the 11-ft. diameter, and the diameter was increased in three stages, namely 12 ft., 14 ft. and finally 15 ft. Anchorage for the 11-ft. diameter spherical valves is obtained by these transitions.

Particular emphasis was given in preparing the specifications for the steel liners to eliminate, to as high a degree as practically possible, failures due to brittle factures of the steel. The steel plate thickness varied from 1½ in. to 3 in., which is matter for much consideration where brittle failure is likely to occur. Every plate was subjected to Charpy impact tests and all welds were low temperature stress relieved followed by full radiography.

Due to shipping limitations, the larger sections were made up in cans about 8 ft. long at the place of manufacture and then were assembled into 30-ft. sections at Isle Maligne, Quebec. Final assembly of the penstocks was accomplished by transporting the 30-ft. sections by truck to Chute-des-Passes, placing them directly into the excavations, and then hand welding the final circumferential seams. Excellent results were obtained from all welding with less than 1% of cutout and repair.

The liners were finally encased in concrete and grouted to ensure full contact between the surrounding concrete and rock.

It is interesting to note that the minimum steel thickness of 1½ in. was determined solely from the anticipated effects of external water pressure which may occur upon dewatering of the tunnel and penstocks.

Powerhouse

The power station proper is in an excavated cavern 473-ft. long, 65-ft. wide, 105-ft. high, and located some 450-ft. below the earth surface. Access to the station will be either through a 36-ft. diameter adit tunnel 2,400-ft. long or by means of a passenger-freight elevator running between the control block floors and a surface entrance building.

There will be a passenger elevator operating between floors at the control block end. To reduce the fire hazard, the oil storage tanks will be placed in an oil storage room having fireproof doors, the whole being located in a tunnel leading off from the main access tunnel. In addition, a transformer to be repaired can be lowered into a fireproof vault located below the service bay floor. These areas are covered by sprinkler systems. Fig. 7 is a cross-sectional view of the powerhouse in which can be seen the inlet valve, turbine, draft tube and manifold, generator and generator bus shafts leading to the surface. The draft tube manifold is a chamber 410-ft. long, 62-ft. wide and 102-ft. high, nearly as large as the powerhouse chamber, and is vented to the surface by a vertical shaft about 450 ft. high. Each of two over-head cranes has a rated capacity of 210 tons on the main hook and 25 tons on the auxiliary hook. The two cranes can be interconnected through an equalizer beam for lifts heavier than the capacity of one unit. The 25-ft. high by 30-ft. wide draft tube discharge openings are equipped with gate guides and one gate is provided to permit unwatering each unit separately.

The ventilating system is divided between the powerhouse proper and the control block. The powerhouse is supplied with air by two 100,000 c.f.m. centrifugal fans located on the machine shop floor, which will draw air from the surface through the main access tunnel, the air afterwards being united with a controlled portion of recirculated air, and discharged into a room in which cooling coils may be installed in the future. From the coil room the air enters a passageway, also used as a cable gallery, along the downstream side of the turbine floor and from there is distributed to the various sections of the powerhouse. During the warm seasons, when only outside air would be utilized with no recirculation, all surplus air will be discharged through the bus shafts. During the colder seasons not less than 10,000 c.f.m. will be discharged through the bus shafts to provide necessary cooling.

The transformer repair room, welding hoods, and oil storage room exhaust into the tailrace chamber and thence up the vent to the surface. Such provision is effected after consideration of both safety measures and disagreeable fumes.

The control block is supplied with outside air from the entrance building on the surface by way of the elevator and stairwell. After mixing with recirculated air, it passes through a system of air conditioning before being delivered to the various rooms. A duct located in the elevator shaftway exhausts to atmosphere air from the washrooms, locker rooms, lunch room, and battery room.

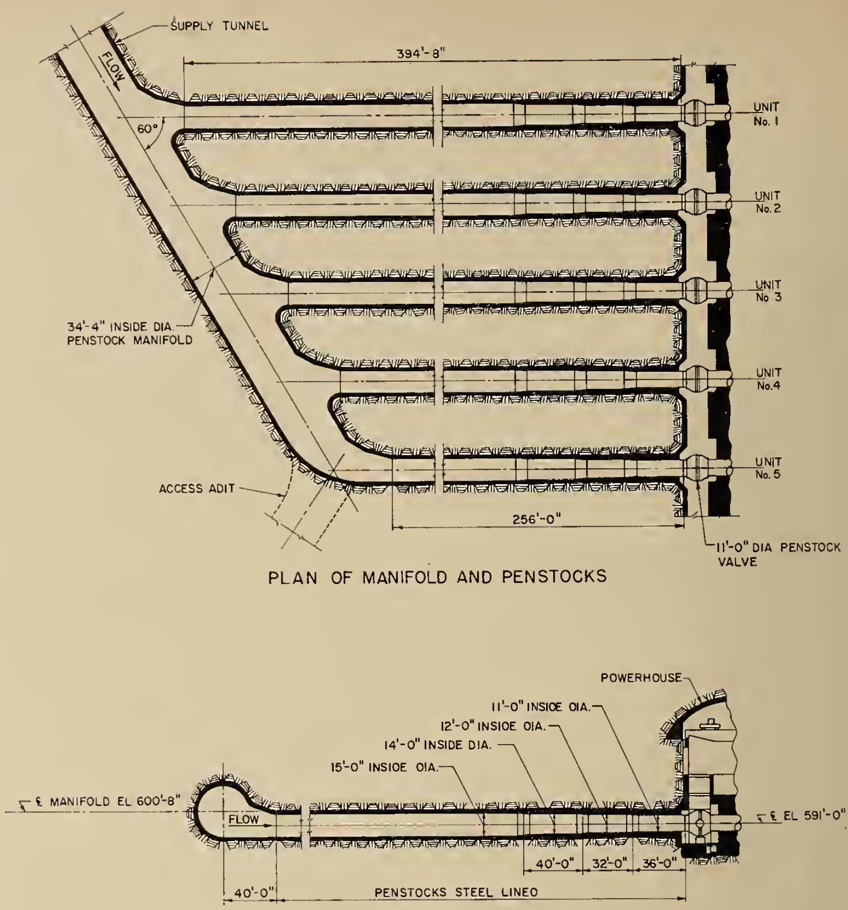


Fig. 6. Plan and profile of penstocks.

Discharge Tunnel and Tailrace

The tunnel, leading from the draft tube manifold to the tailrace is unlined and is 48 ft. in diameter. For construction convenience the circular cross-section was modified giving a relatively flat bottom to permit construction equipment to pass. As with the supply tunnel, the discharge tunnel was driven by the heading and bench method. The only major fault associated with the discharge tunnel was located by means of drilling, and occurred near the exit portal of the tunnel to the tailrace. This required a minor alteration in the location of the exit portal, allowing the fault to fall in the open cut of the tailrace where support can be more easily obtained.

Aside from rock bolting, which was carried out by the contractor during construction, this tunnel required very little support. It is interesting to note that aluminum rock bolts were used extensively in this part of the work to provide permanent support without fear of eventual loss of bolts through corrosion. In addition there are four or five areas where the tunnel passes through narrow bands of altered rock resulting from minor shears. None of these sections is serious enough to warrant extensive support and it has been decided that protection in the form of reinforced gunite keyed into the rock will be sufficient.

The tailrace consists of a large cut through bedrock and extends to the Peribonka River ending at a sill with elevation at 585 ft.

As mentioned previously the draft tube manifold acts as a surge tank for the discharge tunnel which will operate as a low pressure conduit. Thus the tunnel will always flow full under normal conditions. Due, however, to the possible surge conditions, it was found necessary to utilize an unlined tunnel of 48-ft. diameter to minimize the velocities and the magnitudes of the surges. Although the surface area of the tailrace tunnel surge tank is far above that required for stability at normal turbine setting (See Fig. 5) it was not sufficient to prevent the draft tubes from being unwatered under full load rejection. Providing additional area or lowering the turbine setting would have been expensive. Resort was therefore made to constructing a flat weir in the discharge tunnel downstream from the draft tube manifold. The height of this weir will prevent unwatering of the draft tubes.

Table I lists the hydraulic losses associated with each part of the project and the criteria used in determining these losses.

Table I—Hydraulic Losses (Discharge 14,750 C.F.S.)

	Loss (*Feet of Head*)	
Intake		
Entrance—Intake Tunnel ($0.5v^2/2g$)	0.44	
Intake Tunnel 50 ft.–0 in. Horseshoe (n = 0.035)	0.33	
Expansion ($0.15v^2/2g$)	0.13	
Trash Racks	0.14	
Transition and Gate Checks	0.72	1.76
Supply Tunnel		
n = 0.012	25.70	25.70
Penstock Manifold		
n = 0.012	0.05	
Deceleration in Manifold	0.13	
Branch Losses	0.16	0.34
Penstocks		
15 ft.–0 in. Dia.	0.80	
14 ft.–0 in. Dia.	0.21	
n = 0.013		
12 ft.–0 in. Dia.	0.48	
11 ft.–0 in. Dia.	0.54	2.03
Draft Tube Manifold		
Induced Losses (Model Tests)	1.58	1.58
Discharge Tunnel		
48 ft. Dia. n = 0.035	12.00	12.00
Tailrace		
$v^2/2g$	1.04	1.04
Backwater in River above EL 596 ft.–0 in.	4.00	4.00
Total Head Loss in System (Feet)		48.45

Electrical Abstract

The electrical portion of the project involves the following:

1. An underground turbine-generator station having a nominal capacity of 1,000,000 h.p. in five units.
2. A surface switching station including transformers.
3. Two single circuit transmission lines to interconnect with the present Saguenay Power System at Isle Maligne, Quebec.

Station & Equipment

Valves—There is one hydraulically-operated spherical turbine shutoff valve of 11-ft. nominal diameter for each unit as indicated on Fig. 6. The valves consist of a valve body or casing in which a plug rotates to open or close the valve to the flow of water. Two sets of seals are supplied with each valve. The main seal is on the downstream end and will close after the plug is rotated to the closed position. Means are supplied through dismantling sections for replacement of this seal without dewatering the penstock. During such operation the second or emergency seal can be applied on the upstream end of the valve.

The valves are designed for a maximum working pressure of 400 p.s.i. with satisfactory operation at any pressure between 190 p.s.i. and 400 p.s.i. The acceptance test for the valves stipulated a pressure of 600 p.s.i.

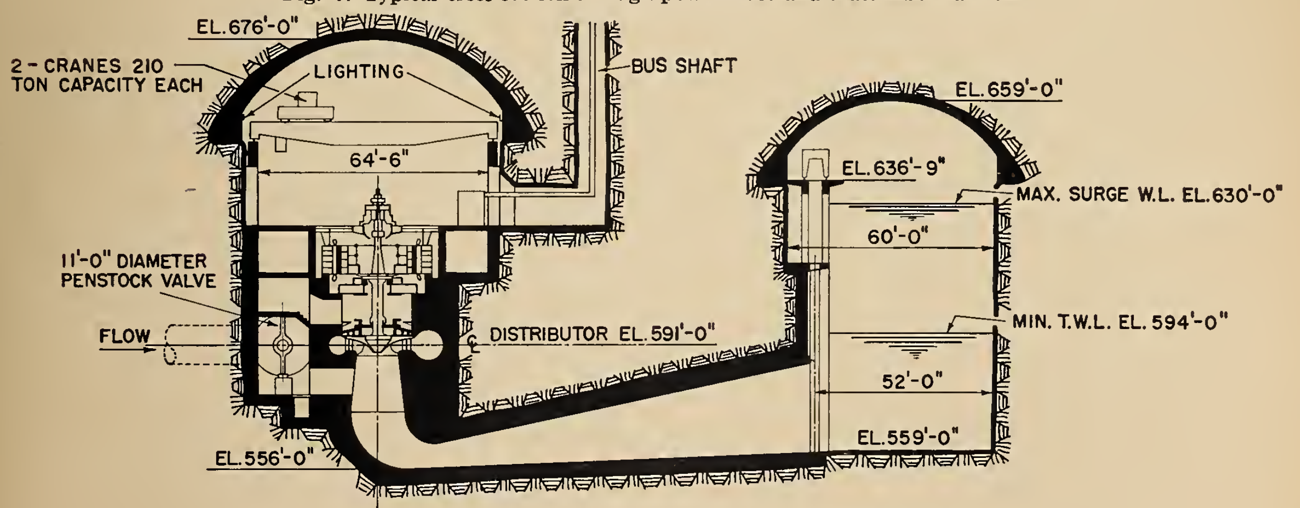
The valves will normally be operated remotely but provision is made for mechanical local operation. The time required to fully open or fully close a valve is approximately 30 seconds and each valve is designed to close against the maximum full gate turbine discharge. It is interesting to note that cooling water for the units and the powerhouse service water is supplied by an eductor system pumping from the tailrace manifold, the high pressure connection being taken from the valve by-pass piping which is normally used to equalize pressure before the opening of the valve.

Turbines—The turbines are of the Francis type, each having a guaranteed capacity of not less than 200,000 h.p. at a net head of 540-ft., and of not less than 165,000 h.p. when operating under a net head of 470 ft. The turbine efficiencies are guaranteed at several net heads ranging from 470 ft. to 590 ft. The foregoing two characteristic criteria are necessary since the elevation of the reservoir, from which the supply tunnel leads, can vary over approximately 100 ft. The turbines have the usual protection against overspeed, loss of governor oil pressure, excessive bearing temperature, low oil or cooling water flow. Table II lists some of the turbine data while the guaranteed efficiency curves are indicated in Fig. 8.

The turbines will be controlled by electro-hydraulic type governors in which a tuned inductance-capacitance circuit and phase-sensing rectifiers replace the normal fly-ball arrangement.

The direct-current output of magnetic amplifiers following the above-mentioned rectifiers operates a moving coil actuator to control the first stage

Fig. 7. Typical cross section through powerhouse and draft tube manifold.



of a hydraulic amplifier system, the final stage of which is the distribution valve controlling the rate of movement of the servo-motor for the turbine wicket gates. With this type of governor the transient response of the units is easily controlled, e.g., by turning a small knob an operator can change the damping from very heavy, which would be suitable for units parallel on the bus but off-load, to very light which would correspond to the on-load condition. It will be possible to operate any number of the units under one joint control with the remaining units, if any, being individually operated.

Generators—The generators are of the umbrella type with the thrust bearing located below the rotor and using the edge of the thrust block as a journal for the guide bearing. The generators are of unfamiliar design in that the generator shaft is merely a stub shaft for carrying the exciter and has no function in relation to the rotor proper. There is a guide bearing at the upper end of this stub shaft. Furthermore, there is no rotor spider in the normal sense of the word. Instead a rotor ring is built up of laminations or rim plates to which the pole pieces are keyed. The rotor ring is keyed to a bracket which in turn is fastened to the thrust block. There is no connection between the bracket and the generator stub shaft.

Table II—Turbine Data

Efficiency and Output	See Fig. 8
Weight of Shaft (pounds)	66,000
Weight of Runner (pounds)	60,000
Weight of Complete Turbine (pounds)	850,000
Turbine W R^2 (pounds Ft.^{2})	1,190,000
Runner Inlet Diameter (inches)	162.5
Runner Discharge Diameter (inches)	145.0
Type of Runner	Cast Steel
Runaway Speed at Max. Head (r.p.m.)	376
Bearing	Self Lubricated

The generators have direct-connected main exciters and voltage regulation is effected through automatic high-speed continuously acting regulators of the static type using rotating amplifiers. Six phase leads are brought out of the unit for split phase protection. The generators will be grounded through a distribution transformer loaded with a resistance such that with a ground fault at the machine terminals the maximum fault current will be about 15 amperes. This should prohibit significant iron burning due to ground faults. Cooling of the generator is accomplished by passing the ventilating air through air-to-water heat exchangers located in each corner of the concrete enclosure. Air-water fog fire protection manifolds are located at the top and bottom of each machine. The usual temperature-detecting elements are located in the stator windings, in the bearings and in the cooling air, and the usual flow alarms in the cooling water lines for the air coolers and bearing. Table III shows the relevant generator data.

As indicated on the foregoing station layout diagrams, the generators are connected to the transformers by means of buses located in shafts rising some 480-ft. to the surface. There is one bus shaft for each generator. Each phase bus is constructed of two 12-in. aluminum channels placed together on edge and supported by post-type insulators. Additional insulators act as spacers between the three phases. The aluminum channel is of 19-ft. sections with expansion joints between adjacent sections. There will be a ladder with safety hoops running the full length of each shaft, with landings at 20-ft. intervals.

As previously mentioned, should a total load rejection occur, the resulting water pressure surge has a period of 10 to 18 minutes. Should load acceptance be attempted on more than one unit when the surge is reaching its minimum level in the surge tank, the water level in the surge tank would drop down into the surge shaft below the minimum acceptable level established for the surge tank design. As an aid to the operators, a surge tank water level indicator and recorder will be incorporated in the control room to enable the operator to determine the existing water level in the surge tank and also the direction of the transient pressure.

Main Power Transformers—Each of

Fig. 8. Turbine efficiency curves.

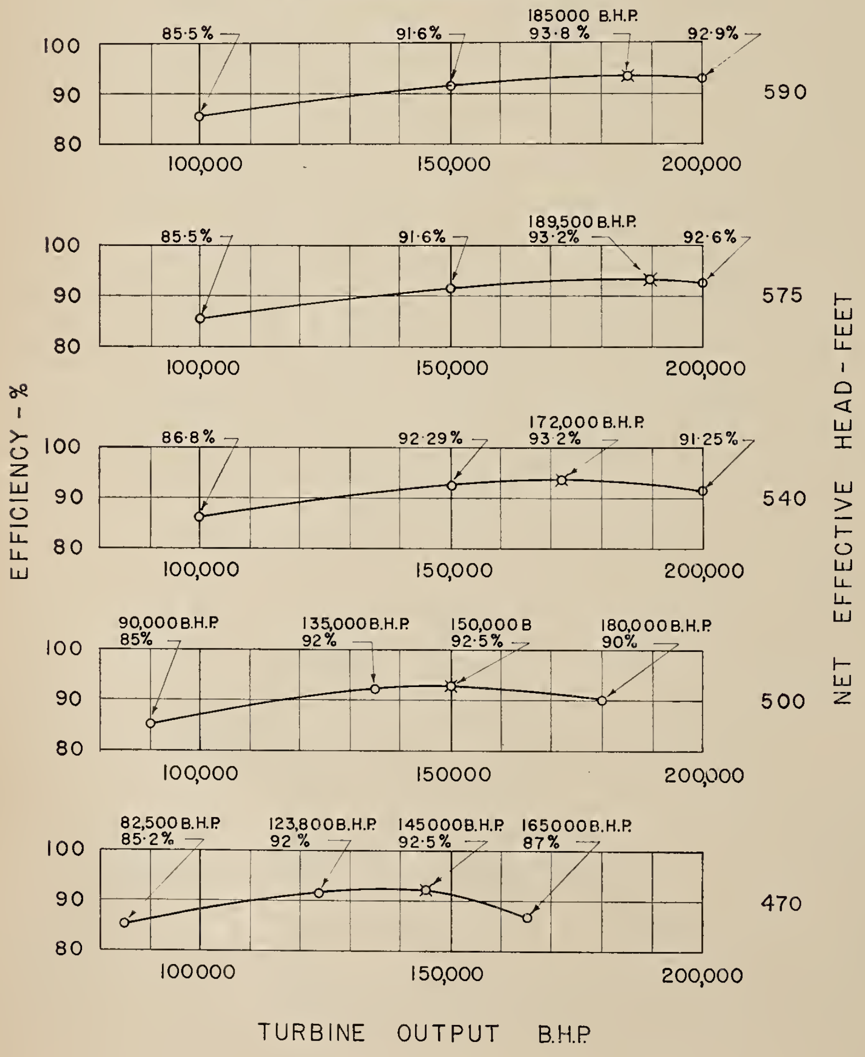


Table III—Generator Data

Output kva at 60° Temp. Rise	165,000
Output kva at 80° Temp. Rise	190,000
Rated Voltage (kv)	14.4
Power Factor (%)	90
Guaranteed Efficiency at Full Load (%)	98.04
Guaranteed Efficiency at 3/4 Load (%)	97.68
Guaranteed Efficiency at 1/2 Load (%)	96.75
All at .90 Power Factor	
Calculated Generator Reactance (%)	
X_d	103.1
X_d'	31.3
X_d''	20.0
X_2 (Unsaturated)	23.7
X_0	9.8
X_q''/X_d'' (Unsaturated)	1.42
Rotor Total Weight (pounds)	840,000
Generator Total Weight (pounds)	1,530,000
Generator WR^2 (pounds)	65,000,000
No. of Parallels in Stator	18
No. of Turns in Stator Coil	5
Type of Stator Coil	Whole Coils

the five main transformer banks consists of three single-phase transformers rated 33/44/55/66-mva, type ONS /ONP/OFP/OFFP, that is, the natural cooling for the minimum transformer rating will be augmented by fans mounted on each bank of radiators and by oil pumps between the bottom headers of the coolers and the transformer tank to give the other ratings specified. The coolers are separately mounted from the transformers and are self supporting, being connected to the transformer by flexible connections. Thus a faulted transformer could be moved exclusive of the coolers, or conversely a complete cooler or individual radiators could be removed for repair with the transformer operating at a load suitable to the cooling means remaining in service. The bank ratio, when the three units are connected delta-wye, is 13.8-385/222.3-kv., with four 2½% full capacity off-load taps below the 385 kv. level. This wide range of voltage control is required to cover the divergent conditions of (a) sending almost the complete station output over one circuit, and (b) two very lightly loaded lines with the generators operating at a slightly leading power factor.

The high-voltage winding is graded from a BIL of 1,300 kv. at the line end to 110 kv. at the neutral point, which will be solidly grounded. The BIL of the low-voltage winding is 150 kv. throughout. All transformers will be constructed with aluminum windings.

It is intended to operate the transmission circuits initially at half-voltage which will permit them to be connected directly to the existing power system without stepdown transformers at the receiving end of the lines. To effect this it will be possible to connect the high-voltage windings of the Chute-des-Passes transformers in a parallel connection rather than in a series connection. With the parallel connection, however, no off-load taps will be available, the bank ratio being 13.8-192.5 kv., the BIL of the high-voltage winding is 650 kv. and the bank capacity is somewhat reduced. The transformer data are shown in Table IV.

High-Voltage Switchgear—The high-voltage circuit breakers are of the air-blast type rated 380 kv., 1,550 kv. BIL and are of the 3-cycle opening class. The interrupting capacity on a symmetrical basis is 15,000 mva for the line breakers and 8,000 mva for the unit breakers. The maximum fault duty will be about 3,300 mva. The breakers will be equipped for either single-pole or three-pole reclosing.

The high-voltage disconnects are standard units with grading rings, with the provision that they are guaranteed to interrupt one ampere of charging current at normal voltage. This will ensure that the various bus sections can be de-energized through a disconnect.

A set of lightning arrestors will be connected to each of the high-tension buses. However, as a load rejection at the receiving end of the lines will result in considerable overvoltage on the Chute-des-Passes bus, the arrestor rating was carefully chosen. For example, under the condition of only two units operating at their nominal rating and supplying both transmission circuits through transformers set on mid-tap, the power frequency voltage would instantly increase to a theoretical value of about 508 kv. L-L or 293 kv. L-N following a load rejection. A rating of 308 kv. was chosen to ensure that the arrestor will be able to reseal should it be required to discharge a surge under such overvoltage conditions.

There will be two single-circuit steel tower lines about 91-miles long, using double conductors per phase of 850-mcm ACSR. A spacing of 16 in. will be maintained between the two conductors of a phase by means of spacing devices located approximately 250 ft. apart. The tower strength was designed so that a third phase conductor could be added at a later date if so desired. The circuits will be protected by double ground wires extending only about one mile from each end of the lines, although continuous ground wire protection could be added if required. Line insulation will consist of eighteen insulators of 10-in. diameter at 5¾ in. spacing, giving a critical impulse insulation level of about 1,600 kv. As the surge impedance loading per circuit at 385 kv. is some 485 Mw, each circuit will be capable of carrying approximately the complete station output.

Table IV—Main Transformer Data
(Series connection of H.V. Winding)

Rating According to Operation (k.v.a.)	
ONS-No Auxiliary Cooling	33,000
ONP-All Fans Operating	44,000
OFP-All Fans and 2 Pumps Operating	55,000
or	
One Half Fans and 3 Pumps Operating	55,000
OFFP-All Fans and 3 Pumps Operating	65,000
Voltage Ratio of Bank	13.8-385/222.3
No. of Full Capacity 2½% Taps below H.V.	4
Reactance LV. to HV. (%)	13
Exciting Current (%)	1.4
Guaranteed Efficiency on 200.07 k.v. at 55 M.V.A. & I.O.P.F.	
Full Load (%)	99.46
3/4 Load (%)	99.51
1/2 Load (%)	99.52
Oil (Imperial Gal. Approx.)	8,430
Weight of Oil (Pounds Approx.)	72,500
Weight of Core and Coils (Pounds Approx.)	98,000
Weight of Tank and Fittings (Pounds Approx.)	66,500
Total Weight (Pounds Approx.)	237,000

Relaying

The generator and transformer protection provided is in accordance with modern accepted practice for such large units. All of the protection operates one of two trip relays, both of which trip the generator field breaker, trip off the voltage regulator, trip the high-tension breaker, and operate the governor to bring the unit to speed-no-load. On units No. 1 and No. 5, from which the station service is provided, the low-tension breakers corresponding thereto are also tripped. The objective is to have some fundamental protection for each piece of equipment on each trip relay. Table V shows the various relays and their distribution between the trip relays. The operation of either the emergency shut-down switch, the unit overspeed relay set at 150% speed, or the loss of governor oil pressure relay, shuts down the unit and closes the penstock valve.

Differential protection will be provided for the high-tension bus. Carrier current relaying of the transfer trip type using impedance relays with overcurrent backup will provide protection for the transmission lines. A complete system of annunciators will be available to monitor the above protective relays as well as those protective devices mentioned previously with the equipment pieces.

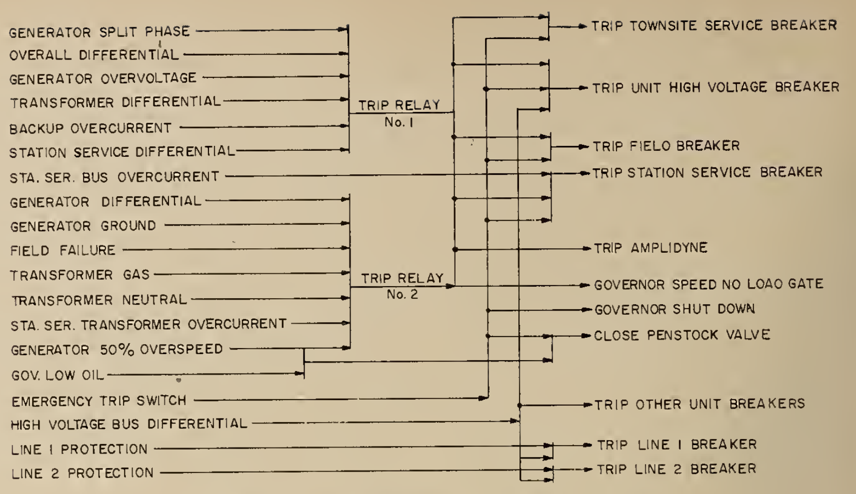


Table V—Arrangement of protective relays

Communications

The primary communication between the Chute-des-Passes station and the remainder of the system will be effected through power line carrier of the single side-band type. There will be four audio frequency channels, three telemetering channels, and one teletype channel. The coupling is phase-to-phase, that is, to one conductor on each of the two transmission circuits. It is believed that this type of coupling results in a lower loss in case of icing conditions on the transmission line and furthermore the loss of one circuit still permits operation phase to ground, although with considerable transmission loss. At three points along the transmission line it will be possible to plug a mobile set into a line coupler and thereby permit communication with either the power station or the dispatching office which is located near the receiving end of the lines. This provision should facilitate line maintenance.

The carrier communication system will be supplemented by normal telephone lines which will also serve the Chute-des-Passes community.

Station Service

The powerhouse a-c. station service will be supplied by either or both of two 1,200 kva., 13,800/575 volt dry type transformers located in generator terminal cubicles No. 1 and No. 5 Each transformer is equipped with a dry type on-load tap changing mechanism covering the range of 11,000 to 15,200 volts. These two sources feed a central distribution board equipped with an automatic throw-over device such that should one source fail, its load is picked up by the second source.

The switching station a-c. station service will be supplied by either or both of two 750 kva., 4160/575 volt dry type transformers located in the surface entrance building. These two transformers are in turn supplied from either or both of two 5,000 kva. 13,800 /4160 volt townsite transformers equipped with on-load tap changing mechanisms located in the switchyard and connected to the buses of units No. 1 and No. 5. An automatic throw-over scheme, similar to that described in the previous paragraph, is also incorporated for this station service supply.

The d-c. control is taken from a 250 volt station battery located in the powerhouse control block. This battery also provides emergency lighting power which automatically comes into force in the event of failure of the a-c. power.

Construction Planning

Located some 90 air miles north of Isle Maligne, the project area was accessible by a road unimproved over the north 100 miles of its 145-mile length and incapable of handling the passage of heavy equipment and other heavy traffic. This north 100 miles was rebuilt and much of it relocated. Work on the road actually began in June, 1956 but as the road was the key to the success of the whole project, the road work was pushed vigorously. By November, 1956 the work was essentially complete and the road had carried heavy traffic long before that date. Bridges and other traffic facilities were designed to carry up to 60-ton net load and this limitation did influence the design of some of the power station equipment. The lower 40 miles of road is public and the bridges there were strengthened as a cooperative effort with Provincial authorities.

While access facilities were being provided, work was going on leading towards contracts for the main project. A unit price or lump sum contract was desired if such could be obtained on attractive terms. The alternative was a cost-plus fixed-fee-type contract. Because it was certain that it would take some time to develop satisfactory project contracts. Alcan assumed direct responsibility to build access roads to within 1,000 ft. of the various working areas of the project, to build an airstrip, to furnish construction power, and to purchase the permanent equipment. Permanent equipment in this case was construed to mean almost everything that would be specified on a construction drawing. Alcan also accepted the responsibility of providing housing for Alcan employees on the job and for the consulting engineer's staff. Review of preliminary proposals from contractors in mid-1956 provided confirmation of early planning and early scheduling and gave better information about probable costs but none were sufficiently firm to be acceptable. In the meantime, much more design information had been developed.

Discussions with contract bidders and analysis of information given in their preliminary proposals led to changes in the final contract bid invitation terms that clarified the more difficult points of uncertainty and probably led to more favourable bidding. The contract was a unit-price contract with lump-sum bids for camp, plant and equipment. The contractor was responsible for all of the construction areas and for construction materials not furnished by Alcan. The contractor started field work in September, 1956.

Certain extra work items were anticipated but not included specifically in the contract, anticipating negotiation of unit prices later. Failing negotiation the work could either be awarded to an outside contractor or performed by the general contractor on a cost-plus fixed-fee basis with a predetermined schedule of fees. Certain items, such as tunnel supports, grouting and guniting were intentionally omitted from the contract on the basis that too little was known to establish firm unit prices at the time of the contract award. Subsequently, firm unit prices were negotiated.

Construction power was originally planned to be furnished by Alcan but this was added to the general contract. Twelve diesel electric sets of 1,000 kw. capacity each were purchased and set up at the job site. Further studies indicated economies in provision of hydroelectric power for temporary construction services.

Two small hydro units, totalling 10,000 kva. rated capacity had been used by Quebec-Hydro for construction of the Bersimis No. 1 Project. These units were more than fifty years old. They were moved to Chute-des-Passes and installed on the Peribonka River near Adit No. 2 where approximately 50 ft. of head was readily available for development.

Access to underground work was through three separate adits. The first adit (No. 1) was located near the north end of the project, about 7,500 ft. south of the tunnel intake, the second adit (No. 2) 15,000 ft. farther south, and the third adit (No. 3) led directly into the powerhouse, nearly 31,000 ft. from the tunnel intake. Branches from No. 3 adit near the powerhouse provided access to the penstock manifold and main tunnel upstream and to the draft tube manifold and discharge tunnel downstream. The intake areas were accessible from the surface. It was planned that the intake tunnel would be constructed through Adit 1 with alternative access through the intake excavation when this excavation was down to tunnel invert grade. Normal access to the short tailrace channel was through the discharge tunnel as this site was across the river from the other construction sites.

Construction Operations

At each of the three adits to the underground workings a construction camp was built. Each camp, located as close to the portal as practicable, was self-contained and controlled by the superintendent responsible for the work through or near that adit. Each camp had its own construction services. Adit No. 3, the powerhouse adit, was the general headquarters for the field operation by the general contractor, by Alcan and by the consulting engineers.

The underground excavation of the project was the biggest single item. More than three million cu. yds. of rock were taken out from underground.

The contractor started driving the supply tunnel as a fullface heading. Subsequently, he found that there was room for his equipment to operate taking less than the full heading and he changed to a top heading leaving about 12 ft. of the tunnel section as a lower bench to be taken out later. This change in program permitted faster driving and opened up the entire main tunnel quicker, permitting an earlier start on concrete lining. It also improved ventilation sooner. All of the excavation was handled by crawler shovels and truck or trailer units. No railroad equipment was provided at any point. Heavy drifter type drills, mounted on Jumbos that were moved by crawler tractors, did the drilling. The drills were semi-automatically controlled with long-travel feed that permitted drilling with not more than one steel change for the normal driving operation. Muck was loaded by power shovels into dump trailer units with a capacity of 18 cu. yds. These rubber-tired tractor-trailer units proved particularly effective as their ability to make short radius turns and their maneuverability proved an extremely important factor in the very impressive production that has been attained on this job. Two headings were driven from the No. 1 adit and two from No. 2 adit, and some of the tunnel was excavated from No. 3 adit.

Services such as compressed air, water and ventilation air were provided by plants at each adit portal. As Adit No. 1 is 2,283 ft. long, adit

Table VI—Summary of Principal Features, Chute-des-Passes Project

Location	On Peribonka River, 90 air miles north of Isle Maligne, P.Q.
Capacity	One million horsepower.
Water Elevations	*Reservoir* 1240 to 1140 *Discharge* 604, modified by flow conditions in the natural river.
Intake Structure	Located in the bank of the Passes Dangereuse Reservoir where excavation and construction can be done without cofferdam. The Intake Tunnel extends 600 ft. upstream from the gates to deep water in the reservoir. *Bottom of Intake Structure*—160 ft. below high reservoir elevation. *Gates*—2 roller gates 15 ft. wide by 38 ft. high operated by fixed hoists elevated from the deck of the intake structure. *Bulkhead Gate*—Gate slots upstream from operating gate to accommodate bulkhead gate for emergency service to operating gate. One bulkhead gate to be provided. *Trash Racks*—2 sets of trash racks to be provided, serviced by gantry crane.
Tunnels	*Permanent and Construction Access Tunnels*—various sizes, but generally 38 ft. wide—Total length 10,427 ft.
Supply Tunnel	Concrete lined, nominal diameter 35 ft. inside concrete lining; length 30,854 ft.
Discharge Tunnel	Unlined diameter 50 ft.; length 9,137 ft.
Power Chamber	465 ft. long, 65 ft. wide, 48 ft. high from generator floor, but 120 ft. from low point in draft tube. Located about 450 ft. below the surface.
Draft Tube Manifold—Chamber 410 ft. long, 60 ft. wide, 102 ft. high. Draft tube discharge openings 25 ft. high by 30 ft. wide arranged to permit insertion of Closure Gate.	
Surge Chamber	130 ft. diameter by 250 ft. deep connected to power tunnel through 30 ft. diameter shaft and located 2,800 ft. upstream from Power Chamber
Penstocks	5 steel penstocks, 15 ft. diameter to 11 ft. diameter branch from concrete-lined tunnel to each of the turbines. Average length is 325 ft. Centreline Elevation is 591.
Penstock Valves	5 double seal, hydraulically-operated sphere, 11 ft. diameter one for each unit. Valves located just inside upstream power chamber wall.
Generating Units	5 turbine-generators, vertical shaft Francis type, 200,000 h.p. each, controlled by electro-hydraulic governors. Low tension power from each generator will be carried through rigid buses through a vertical bus shaft to the substation at the surface 450 ft. above.
Powerhouse Cranes—2 travelling bridge cranes, each with a 210-ton hook and auxiliary 25-ton hook. Crane rails supported on concrete beams carried by concrete columns from powerhouse floor.	

No. 2 is 4,376 ft. long and adit No. 3 is 2,600 ft. long, the service lines are extensive. The compressed-air supply provided at each adit was sufficient to operate only one heading for drilling, so drilling and mucking cycles for the two headings at each adit were carefully planned and controlled to achieve the best production.

Compressed air plants at the three adits had a combined capacity of 28,680 c.f.m. provided by 37 stationary compressors, of which 3 were diesel driven and the rest electrically driven. The maximum connected construction power load was 14,200 kw., of which more than half was for supply of compressed air and ventilating air to the underground work.

To excavate the powerhouse, the access tunnel was ramped up to about the spring line of the powerhouse and the arch excavated. As soon as the excavation was done, this arch was concreted to offer protection for the subsequent excavation work; then the main body of the rock was removed. Excavation of the powerhouse was essentially complete in February, 1958. The zone above the concrete arch was pressure grouted.

The draft tube manifold, just downstream from the powerhouse, is also a very large structure and was excavated in the same manner as the powerhouse. The elevator shaft, the five bus shafts and the vent shaft, that rise from the powerhouse area to the surface nearly 500 ft. above, were all raised from the bottom up.

The surge chamber, located about 2,000 ft. upstream from the powerhouse, was excavated by raising a centre shaft, then expanding downward from the top with the muck fed down through the centre shaft and taken out through the tunnel. To permit simultaneous drilling and mucking during the expanding operations, spiral steps were developed in the main body of the 130-ft. diameter surge chamber. Drilling was done on one step while muck was shoved down the centre hole from another step.

The tailrace tunnel, 48 ft. in diameter, was driven entirely from the powerhouse end of the tunnel. A top heading was driven full length then the bench was removed as a second operation. Loading and hauling of muck was by the same type units as were used in the supply tunnel.

Tunnel driving progress was spectacular. The best week for all four headings of the supply tunnel showed an advance of 1,138 ft. and removal of about 38,000 cu. yds. of rock.

Through weak fault zones in the granite rock of the main tunnel a total of about 700 linear ft. of tunnel was protected by steel arch ribs. Steel rib supports were also used for 466 ft. of construction adit tunnel. Elsewhere, extensive use of rock bolts provided effective protection. Where concrete lining is planned, as in the supply tunnel and in the powerhouse and draft tube manifold arches, the rock bolts are embedded in concrete and the corrosive properties of the steel bolts used were not considered serious. For the tailrace tunnel, after satisfactory field tests, aluminum alloy rock bolts were used to eliminate the corrosion inhibiting measures necessary to preserve rock bolts made of steel.

Concrete was supplied by a central mixing plant located above the tunnel near adit No. 2. A hole was driven below the concrete plant down into the tunnel and mixed concrete dropped through it to the tunnel level to save hauling distance and to achieve additional freedom from outside weather. It was originally estimated that the total project would require 420,000 cu. yd. of concrete but the actual quantity will be about 580,000 cu. yd. The biggest item of concrete is in tunnel lining of the pressure tunnel, which started on 30th April, 1958. Tunnel arch concrete was placed by pumpcrete into a movable form 160 ft. long. Concrete was hauled in bulk in the end dump trailer units from the drop pipe near Adit No. 2 to pumpcrete machines at the form. The concrete supply system and equipment at the form, all mounted on wheels, was impressive. To the 160-ft. long steel arch form and carrier was attached a ramp, a turning table, concrete remix and pumpcrete machines. The whole assembly was some 370 ft. in length, mounted on wheels and moved as a unit. The volume of pours behind this form varied from 1,200 to 1,500 cu. yds. Normally this assembly placed one 160-ft. section each day.

The concrete lining procedure was to place curbs on each side of the tunnel to accurate line and grade. These curbs had embedded inserts to which the arch form section could be bolted tightly against the vertical curb faces. The concreting equipment rolled on the top of the curbs. The arch concrete was then completed. Invert concrete was hauled in bulk by the end dump tractor-trailer units and delivered to a travelling screed by belt conveyor. The bulk of the concrete placed on the project was delivered to forms by pumpcrete machines. In the intake and low sections of the powerhouse and a few other miscellaneous sections, concrete was delivered to forms in buckets.

The surge shaft lining was placed as a continuous operation through the entire 350 ft. height.

The aluminum switchyard structure had to be located on a hillside requiring heavy fill. This fill was provided almost entirely from the material excavated from the surge chamber retention tank nearby.

Installation of the major items of equipment such as turbines, generators, valves, gates and penstocks is being done by the suppliers of this equipment. By far the major part of the work has been done by the General Contractor or his sub-contractors, but a fair amount of work is being done by local area specialty contractors working directly for Alcan. Progress has been very close to schedules prepared early in the program.

Construction of the intake tunnel (See Fig 3) presented unusual problems. Tunnel driving proceeded from Adit No. 1 through the intake to the intake tunnel. The rock fault was encountered when the tunnel heading was under the reservoir and the structure of the rock there was sufficiently

Table VII
Major Construction Equipment, Chute-des-Passes Project

38	Air compressors—28,600 c.f.m. in 3 central plants
141	Heavy Duty Drifter Drills
11	Wagon Drills
56	Jackhammers and Paving Breakers
43	Stoper Drills
50	Passenger Cars and Pickups
10	Service Trucks
8	GMC Dump Trucks
11	End Dump Mack Trucks
14	D8 Tractors (cat)
32	Cat Model DW-21 with PR-21 Athey Wagon
4	Cat 12 Graders (3) Cat #112 (1)
3	a-c. Hd-9 with Giraffe Hydraulic Platform
1	Cat Grader with Giraffe Platform
7	Diesel Shovels 12 to 22 cu. yd.
4	Electric Shovels 1½ cu. yd.
5	Truck Cranes
3	Bullmoose Cranes
12	Diesel-Electric Generators 1,000 kw units
1 set	Steel Tunnel Lining Forms—160 ft. long
2	Hydro-Electric Units and Power Station, 10,000 kva.
4	Bombadier Muskeg Tractors
3	Eimco Overhead Loaders
3	Mack Truck Tractors
51	Ventilating Fans
11	Steam Boilers Total 2,300 h.p.
5	Heavy Duty Trailers
6	Rex Pumpcretes
4	Koehring 4 cu. yd. Tilting Mixers in Central Mixing Plant
1	Concrete Aggregate Crushing and Screening Plant
8	Euclids—87 FD
5	Mack Trucks with 5½ cu. yd. Transit Mixers

broken to give concern that major leakage through the tunnel arch might develop. This concern led to the decision to construct a concrete bulkhead downstream from the intake with a removable gate to be closed when blasting and opened for access. It also led to excavating a small exploratory heading all the way upstream to the bottom of the rock plug planned for removal by a single blast to admit water to the tunnel system. This small heading was then expanded in short sections to the arch excavation line. As excavation of each section was finished, the concrete arch was placed and the process repeated until the arch was concreted up to the plug. Through the fault zone, the arch was supported on concrete walls placed by "underpinning" technique. Slots were expanded outward from the centre of the tunnel and concrete placed under the arch. Then adjacent slots were expanded until the underpinning required was complete.

The development, drilling and blasting of the rock plug is a story in itself. Briefly, the procedure followed was to extend inclined access shafts upward into the mass. Holes were drilled upward through the rock plug into the reservoir to check the location and character of the rock at the bottom of the reservoir. This exploration showed deep crevassing and the average thickness originally estimated as safe for the plug was increased to 50 ft. to insure safety of the operation. The result was that the sump planned to receive the blasted rock had to be substantially larger than previously planned. The sump volume required was set at 22,000 cu. yd. and the shape of the top half of the opening was determined as the result of model tests.

The contractor developed and built a nearly vertical skip hoist to lift this rock out of the sump and this skip dumped directly to the end dump trailer units. A diesel shovel and bulldozer were fitted with armor and remained in the hole as blasting was carried on. The equipment was then disassembled and lifted out of the 150-ft. deep hole.

Fig. 9. The blast on 19th April, 1959, removed the rock plug, and water filled the intake tunnel. 60,000 pounds of explosive removed 13,000 cu. yd. of rock (rapid sequence film).

The plug was loaded with explosives placed in drill holes and in coyote concentrations in the interior of the mass. The shot effectively removed the plug on 19th April, 1959, filling the intake tunnel with water as far down as the concrete bulkhead. After cleanup of the gate area and diver inspections, the gates were closed and the concrete bulkhead removed.

Plans have been made for permanent housing for operators on a hillside directly above the powerhouse. The site, topographically, is as good as any in the vicinty and offers further advantages of proximity to the powerhouse and a very attractive vista toward the south. Planned to serve an ultimate 80 homes, with schools, commercial and other community needs, roads have been graded and underground water and sewer lines have been placed for the first 40 units and community buildings. Part of the school and 6 permanent houses are completed as part of the initial project.

Procurement

Alcan supplies permanent materials and equipment at the railhead at Isle Maligne where nearly all of the materials for the project are delivered and despatched the 140 miles to the Chute-des-Passes project by truck. The trucking operation is a sub-contract of the general contractor. Storages for cement, diesel oil, grease, fuels and general construction supplies are provided at the site by the contractor.

Manouan Diversion

The project described above does not include one of the important parts of the Chute-des-Passes power project. Lake Manouan above the present reservoir is controlled, and water releases generate power through the existing Peribonka plants and the other plants downstream. Manouan Lake water will be further controlled and released into the Passes Dangereuse reservoir so that it can generate also through the Chute-des-Passes plant. This requires a substantial canal-excavation job, about 1.5 million cu. yds. and a control structure for which surveys have been largely completed and for which some preliminary work has been done. It was originally planned to do this work immediately, but completion has been postponed until after the power plant goes into operation. The proposed Lake Manouan-Bonnard River canal is located almost 100 miles north of Passes Dangereuse Dam and access is by water and road, or by air.

Table VIII—Major Construction Quantities, Chute-des-Passes Project

Underground Rock Excavation	
Tunnels and Surge Chamber	2,620,000 cu. yd.
Powerhouse and Draft Tube Manifold	240,000 cu. yd.
Intake	200,000 cu. yd.
	3,060,000 cu. yd.
Surface Rock Excavation	260,000 cu. yd.
Concrete	
Supply Tunnel	448,000 cu. yd.
Power Chamber	47,000 cu. yd.
Intake	45,000 cu. yd.
Surge Chamber, Adit Plugs, Misc.	38,000 cu. yd.
	578,000 cu. yd.
Steel Arch Supports	1,166 Lin. Ft.
Rock Bolts	120,000

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THE NEW AKLAVIK

Search for the Site

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AKLAVIK, the main settlement of Northwestern Canada, is located in the delta of the Mackenzie River about 68°N. (Fig. 1). This places it in approximately the same relation to the Arctic Circle as Fairbanks in Alaska (65°N), Reykjavik in Iceland (64°N), Narvik in Norway (68°N) and Murmansk in the USSR (69°N). Compared to these other cities, Aklavik is a relatively small place with a permanent population of about 400, which increases to possibly 1500 during the short summer season when Indians and Eskimo come to visit the settlement. Despite this it is the most important Canadian outpost north of the Arctic Circle, and it will almost certainly steadily increase in importance with the development of the Canadian North.

The decision of the Government of Canada in 1953 to move the entire settlement to a new site is a matter of importance to all Canadians. This was the first step in a development in connection with a town which is almost without precedent, apart from such special operations as the move of some mining communities (notably Sherridon to Lynn Lake) and the current work in relocating some of the municipalities on the Canadian side of the St. Lawrence River. The decision to make the move was taken only after the most exhaustive studies. The selection of a new site was correspondingly made only after a most thorough investigation. It is the purpose of this paper to explain briefly the reasons for the move of Aklavik, the requirements for the new site, and the means employed in carrying out the field survey work which eventually resulted in the selection of a new location for this northern outpost.

The start of Aklavik can be dated as recently as 1912 when a small fur trading post was established. In 1919 the famous Anglican Mission was started. The R.C.M.P. established a detachment at Aklavik in 1922 and the first building of the signal station of the Royal Canadian Corps of Signals was built in 1925. The Roman Catholic Mission was started in 1926 and in this same year the adjacent post of the Hudson's Bay Company (on the Pokiak Channel) was relocated. By 1931 population of the settlement and the surrounding area had reached about 400. Today the population of the town and the surrounding delta country exceeds 2000, of whom about 30% are white, 20% Indian and 50% Eskimo; many of the Indian and Eskimo children live in the schools operated by the two churches.

In addition to being the location of the agencies already noted, the town is an important administrative centre for the Department of Northern Affairs and National Resources which is responsible for the administration of the Northwest Territories. More recent establishments have included a Department of Transport radiosonde station and a naval signal station. The town is supplied with electric power by a local power company and is served by two river transportation companies. A scheduled mail and freight air service from Edmonton is operated by Pacific Western Airlines.

The Mackenzie Delta

Aklavik owes its strategic location to the fact that it is on one of the main navigation channels in the delta of the Mackenzie River (Fig. 2). This is one of the greatest rivers of the world, eighth in order of magnitude based on discharge, eleventh in the size of its drainage area and so about 50% larger than the St. Lawrence. The Mackenzie System is navigable by shallow draft boats for 1600 miles from rail head on the Clearwater River at Waterways, Alberta, to the Arctic Ocean, with only one break—the 12-mile stretch of rapids on the Slave River between Fort Fitzgerald and Fort Smith at the northern boundary of Alberta. River transport is therefore operated in two stages on the upper and lower sections of the river system.

Because of the great load of sediment which the river carries, its delta is spectacular (Fig. 3). It is one of the most remarkable physiographic features of Canada, but because of its location it is not as well known as some other major river deltas of the world, even though it is the twelfth largest. From Point Separation, where the delta properly starts, it is approximately 150 miles to the Arctic Ocean. Unlike other deltas it is confined—on the west by the Richardson Mountains and on the east by the Caribou Hills and other high land that is a result of glacial action. Its maximum width is about 50 miles. Of this immense area about one half is water in the form of meandering channels and backwaters, small ponds, and many cut-off *(oxbow)* lakes.

The level area of the delta is nowhere more than from 10 to 15 ft. above normal river level, and much of the area is flooded during high water in the spring. Such land as there is appears generally to consist of silt covered by the inevitable muskeg growth so typical of the North. This makes an ideal area for the breeding of muskrat and the delta is well known as a muskrat hunting area. In the 5,275 square miles of the delta there are over 900 people dependent on trapping. Income from muskrat furs has been declining during recent years and this is creating a local problem. This is only one of the many problems regarding the future of Aklavik, however, which have had to be faced by those responsible for its administration.

Reasons for the Move of Aklavik

The entire delta area is perennially frozen so that the ground consists of material that can be described by the popular name *permafrost*. This condition indicates that the temperature of the ground for an appreciable distance beneath the surface (possibly 1000 ft.) is below freezing temperature, apart from the upper few inches which may thaw during the heat of summer. The soil on which Aklavik rests is an organic silt with a very high natural moisture content. Subsurface investigations for the formation of a new school, which were carried out in 1953, showed that about 60% by volume of the frozen fine-grained soil consisted of ice. If, therefore, the old town site were further developed with a further clearing of the muskeg cover and the installation of heated buildings, ground subsidence would occur with serious results.

The old town site is located on a bend in one of the navigation channels. The entire area adjacent to this site is flat and drainage has always been a particularly difficult problem. One feature of the area is stagnant pools of water formed by the melting of permafrost. Subsurface drainage is impossible and the ditches that are dug for surface drainage tend to complicate the drainage problem by causing still more thawing of the permafrost.

Because of the subsurface conditions, the laying of sewers or watermains beneath the surface would similarly create serious problems. To locate them above ground level and then to connect them to existing buildings would be costly and unsatisfactory for the existing town conditions.

The area used for the town is hemmed in by the bend of the river and by swamps and ponds. There is, therefore, no practical way for the town to expand, and expansion is vital if Aklavik is to fulfil its role as the centre of administration for northwest Canada. Not only is the present site restricted but it is even getting smaller because for some time the river bank has been eroding badly near the Roman Catholic Mission. Works to stop this natural action have been estimated to cost several million dollars and their success would be questionable.

Finally, if Aklavik is to serve properly the expanding needs of the North, it is essential that it should have available to it an airport that could be used throughout the year. Now each year, during the break-up period in the spring and the freeze-up period in the fall, the town is cut off from all flying services. Attempts have been made to construct an airstrip adjacent to the present town but the subsurface conditions are such that this has proved impracticable. A small strip for very light planes does exist, but only with the expenditure of vast sums of money could a major airstrip be developed.

These were the main factors that had to be considered with regard to the future of Aklavik as an expanding community of the North. Confirmation by detailed soil testing of what had been suspected about subsurface soil conditions finally showed the need for over-all consideration of the entire problem. It was this study that finally led to the decision that the only possible solution was to find a new site for the town.

Requirements for the New Site

Before any work could be done in attempting to locate a new site a clear picture had to be developed of the requirements that any such site would have to meet. These could then provide the guide posts for those who were to conduct the actual survey.

The essential factors for any new town site were determined as follows:

(a) the site must be suitable from economic and social points of view;

(b) the site should be suitable for the installation of permanent sewer and water systems, building foundations, and roads;

(c) the site should be on, or very close to, a good navigation channel within the delta;

(d) the site must have reasonably close to it a suitable area for the construction of a permanent first-class air field;

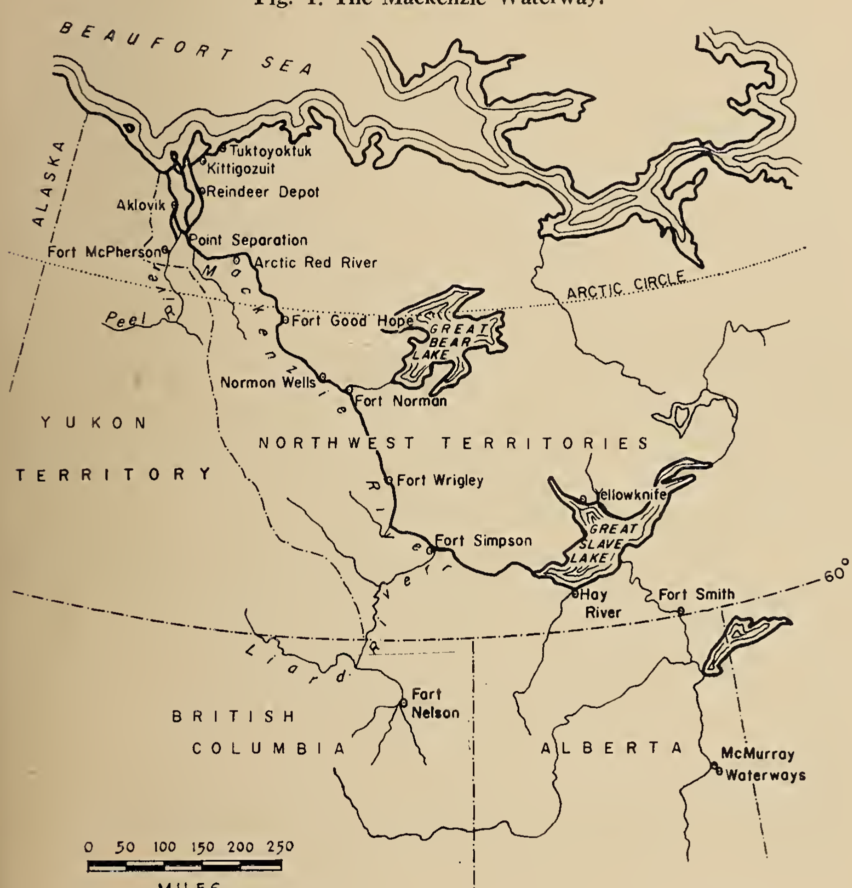
(e) there should be, within economical distance, a suitable public water supply.

The following were regarded as highly desirable features but were not quite so important as those already listed:

(f) the site should provide for economical and convenient disposal of sewerage;

(g) it would be convenient if there were a good supply of gravel and sand

Fig. 1. The Mackenzie Waterway.



nearby for building purposes;

(h) from the navigation point of view it would be desirable if the wharf facilities could be used as a trans-shipment point for freight from river vessels to sea-going vessels which could sail out into the Arctic Ocean.

Finally, the following three factors had to be kept in view as desirable but in no way essential:

(i) availability of a good wood supply;

(j) availability of coal for heating purposes, and

(k) if possible, availability of water power which could be used for the generation of power for public supply.

Organization of the Survey Team

In January, 1954, when the requirements for the new site were specified, the agencies to be represented on the survey team were selected. These agencies were the Department of National Health and Welfare, the National Research Council (Division of Building Research), the Department of Northern Affairs and National Resources, the Department of Mines and Technical Surveys, the Department of Public Works, and the Department of Transport. To the Department of Northern Affairs was assigned the task of placing a team on the ground by March 15, 1954. The survey was to extend through late winter, spring, and summer and the team was to report its findings by August 1, 1954.

The personnel included men trained in the social and physical aspects of the geographic, geologic, and engineering sciences. (See Appendix A for members of the team.) Each agency had responsibilities in the Aklavik area. The Department of Northern Affairs, with the primary administrative responsibility, provided the project manager, C. L. Merrill.

In the few weeks during which the team was recruited, winter clothing, rations, camping and surveying equipment were obtained and, when necessary, shipped to Aklavik. During the winter the only means of getting in supplies was by air. At the same time, relevant information was obtained from reports of earlier expeditions and from representatives of the Royal Canadian Mounted Police and other organizations in Ottawa. Studies of air photographs, already initiated at the National Research Council, were continued in Ottawa until the time of departure of the team, and thereafter in the field.

In addition to the representatives

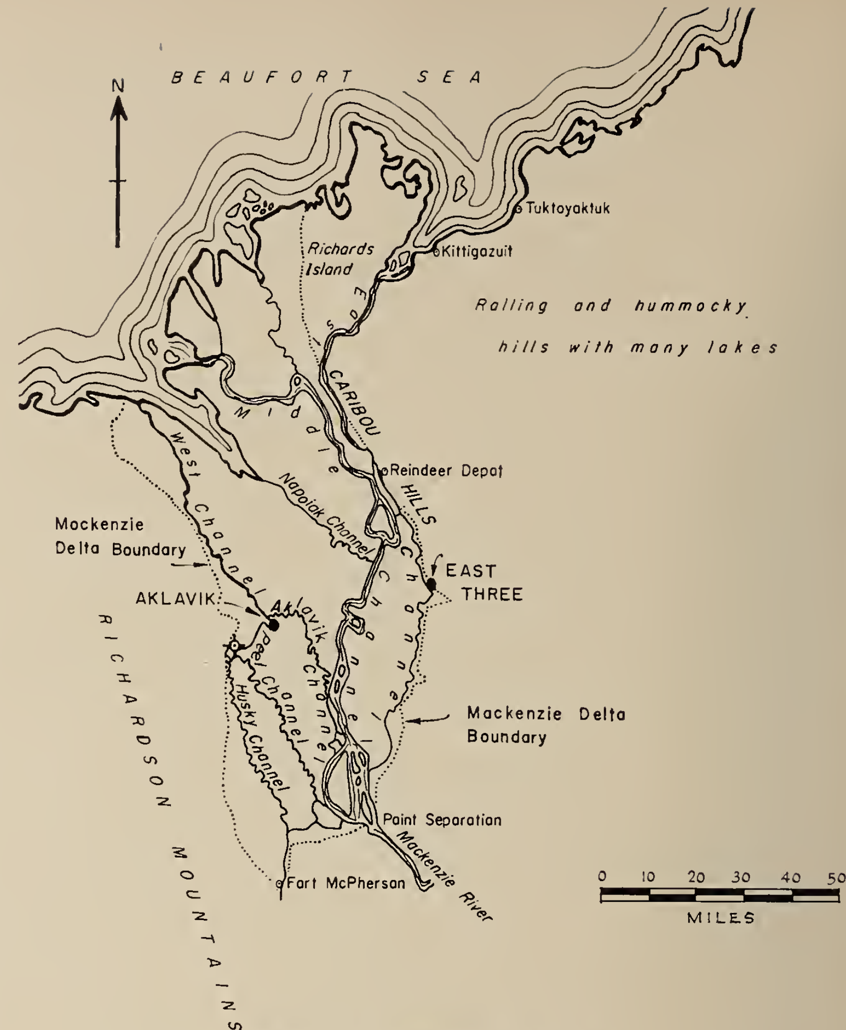


Fig. 2. The Mackenzie River Delta.

already mentioned who were recruited from personnel located at Ottawa and Edmonton, the team was assisted by local departmental representatives "ex officio". The Department of National Defence and the R.C.M.P. unit at Aklavik provided advisory members to the team. Their expert local knowledge proved to be of great value.

The benefit of other local experience was obtained through a Local Advisory Committee. This Committee included representatives from each racial group and from the traders and missions. The first meeting was held before the team established a camp; other meetings were called at intervals as required. In this way, not only was local experience made available to the survey team, but the residents of Aklavik were kept directly advised of the survey's progress.

The Use of Air Photographs

One of the most important early tasks of the survey party was the examination of air photographs covering the entire delta of the Mackenzie River. The techniques of air photo interpretation and identification are increasing in use, especially for the North. The advantages of using air photographs for a preliminary view of the field terrain conditions were appreciated by the survey team. Thus by examining in Ottawa the terrain to be covered by the survey, a preliminary appraisal was made of the problems that would be encountered.

An air photograph records every surface feature to which it is exposed. At first sight this can be confusing since the photograph records these details in many shades of black and white. If, however, the air photographs are viewed stereoscopically (three - dimensionally) the various land forms, and to some extent the variations in the vegetal cover, are soon apparent. After the air photographs are thus examined, similarities in terrain soon become clear. These terrain similarities or *patterns*, as they are most commonly described, are recognized by means of land form, vegetal cover, and photographic tones in a manner similar to the way in which one identifies various acquaintances by their stature and facial features. The land form patterns are then roughly delineated and sampling is carried out in each pattern. If the interest of the observer is the engineering use of soils, the identification of soils in various patterns is attempted. Thus instead of taking soil samples at regular intervals, samples are taken in strategically located positions in the land form and similar soil conditions are assumed for similar patterns. In this way preliminary sampling is greatly reduced.

Using these techniques, members of the survey team, working in the Building Research Centre in Ottawa, carefully examined aerial photographs of the entire area of the Mackenzie Delta. Twelve sites were selected as worthy of detailed study in the field. Their locations were accurately determined and salient features were noted for investigation in the field. The actual saving in time and money which this use of aerial photographs effected cannot be estimated with any accuracy but it is safe to say that, without this preliminary office work, the survey could have been only partially completed in one working season.

Fig. 3. A typical view of the Mackenzie River delta looking west at the Richardson Mountains.

The Survey: Aerial Reconnaissance

The survey party assembled at Aklavik during March 1954. This early field arrival date was fixed so that observations at potential townsite areas could be made under late winter conditions, during spring break-up, and during the summer season. Spring break-up records for the Mackenzie River delta are virtually non-existent and since this period is critical for any town, a helicopter was chartered for the survey period until well after break-up (Fig. 4). The helicopter was first used to make a winter reconnaissance of the potential site areas selected in Ottawa by the use of air photographs. The original selection of twelve sites was quickly pared down to six since some of the potential sites were obviously unsuitable when examined in the field. During these initial helicopter reconnaissance flights, notes were also made on the depth of snow cover and ice thicknesses of the river channels at the sites.

The helicopter had to be maintained remote from repair facilities, with a staff of only one pilot-mechanic, in air temperatures as low as −30°F (in April 1954). During its service of 73 days, flights were logged on 69 days. (The machine was out of service for one day due to mechanical difficulty and for three days because of unsuitable weather.) A total of 201 sorties was flown for a total of 164 flying hours. Although the three-seat *Hiller* machine could carry the pilot and two passengers, it was found that the pilot and one passenger, usually with some survey or other gear, proved to be more effective in the work. The aircraft had a flying speed of 70 miles per hour and carried sufficient fuel for 3 hours flying with one passenger. All parts of the area under investigation were accessible in less than one hour from one of the base camps established.

Fig. 4. Spring break-up at Aklavik, June 5, 1954.

Field Investigation at Four Sites

The survey was conducted from a series of base camps from which investigations were carried out at each prospective townsite as the season progressed. Base camps were located in turn at four of the possible townsites. The more time-consuming operations, such as topographic and hydrographic studies, and soils investigations, were conducted when the base camp was at, or near, the site of the work. Use of the helicopter, and in summer a fast boat, made it possible to carry out some work at each potential townsite throughout the field season, regardless of the location of the base camp. In the course of field investigations the team was housed in tents. The cook, a driller's assistant, and several labourers were hired locally. The base camp was moved by tractor train, dog team, and by a small barge and scows, all obtained locally, as seasonal conditions dictated.

The first base camp was set up at

a potential site approximately 12 miles southwest of Aklavik. This site was located on the alluvial fans of the Richardson Mountains. The camp was located at the junction of the delta and the fans near the Husky Channel and so was called the Husky Site. The camp was set up during the beginning of April and consisted of two 16 x 16 ft. tents and some other smaller tents. All of the camp equipment was brought to this site by tractor from Aklavik.

Unfortunately the region experienced one of its coldest Aprils on record and this restricted much of the soil sampling. For the first two weeks in camp, the temperature rarely rose above 0°F and went down at night to as low as −30°F. An attempt was made to drill during this interval but the problems of supplying drilling wash water soon forced its abandonment until air temperatures rose above 10°F.

The drilling equipment used was a modified version of a permafrost drill developed by the U.S. Corps of Engineers (Fig. 5). It is essentially similar to a diamond drill using wash water to carry away bit cuttings, but uses a hard metal insert bit (*carballoy*) instead of a diamond bit. A notable feature of the rig is that it is made of lightweight materials and can be broken down into small light components for easy transportation by bush aircraft. The special feature of drilling and sampling in permafrost is not the equipment used but the amount of wash water and the skill with which it is used. If too much wash water is fed to the face of the bit to carry away frozen soil chips, there is a danger of melting and washing away the core, even though a double-tube type of core barrel is used. On the other hand, if too little wash water is used, the frozen soil cuttings soon form a slush with the wash water which can quickly freeze in the core barrel. No rules can be formulated for the amount of wash water to use and the correct amount is best determined in the field.

After the samples were obtained from the drilling, representative split cores were photographed in colour before soil samples were taken. These photographs were invaluable later when the soil test results were available and references were required to the types of frozen soil encountered. The samples were shipped to Norman Wells for routine engineering soil identification tests including determinations of moisture content, grain size, Atterberg limits, and natural densities.

Fig. 5. Drill rig operation before airlift to next drilling location. Tent in background provides shelter for soil sampling and photographing frozen cones.

Break-up observations were started during May. These consisted of establishing observers at the potential townsites to record channel water levels and to assess the damage, if any, caused by the moving ice. During the break-up interval of the delta, daily reconnaissance flights were made with the helicopter and the rate of progress of the moving ice and general water levels was observed.

After break-up, the survey party proceeded to the east side of the delta and carried out terrain studies at two potential sites known as *East Three* and *East Four*. Two more of the east channel sites were eliminated as potential townsites because of their low-lying topography and possible difficulties in reaching them by river transport. After the east channel sites had been investigated, the party completed its investigations at another site on the west channel. This site was purposely left until the end of the survey since snow cover remained at this location until June and made terrain investigations difficult.

After the four finally selected sites had been investigated, the survey completed its field reports. A preliminary appraisal indicated the site known as *East Three* to be the most favourable. Even though a final decision on the new townsite could not be made until the fall of the year, the need for design data from the chosen site was anticipated. Accordingly the month of August and part of September were spent in making a detailed terrain analysis of *East Three* and collecting soil samples for a better understanding of the soils at this site.

Description of New Site: East Three

The central part of the eastern delta flank is predominantly a huge glacial moraine. In the southern part, bedrock is exposed through the glacial deposits; in the northern part, in the latitude of the Reindeer Station, the moraine is built up around the Caribou Hills. *East Three* is located between the areas of bedrock to the south and the Caribou Hills to the north where the East Channel flows along or close to high ground of glacial origin.

The relief of the area is one of flats at varying elevations, gentle undulations separated by shallow swales, rounded knolls, hummocky hills and ridges of varying heights and lengths. To the north are two terraces at elevations of 60 and 150 ft., and to the south a series of elongated smoothly rounded hills (drumlins) aligned in an east-and-west direction, with a swing to the north as the channel is approached. Some of the low-lying areas between the hills are occupied by small lakes.

East Three is drained to the west and northwest by streams which emanate from deep gullies in the high interior upland. The drainage is controlled by the relief, especially in the southern part of the area where the streams flow in parallel courses between the ridges. As a rule the ridges, knolls, and undulations are well drained although some of the relatively lower areas are not.

Spruce and birch are the dominant tree types, with secondary stands of willow and alder. The ground is generally hummocky with a varying cover of moss and shrubs. Birch predominates on the south-facing slopes and on well-drained areas. Spruce predominates on the north-facing slopes; stunted spruce, willow, and alder are found on more poorly drained areas.

Few trees grow on the low flat areas except along stream courses where there are dense thickets of willow and alder.

At *East Three,* frozen ground was encountered in September at depths varying from 6 in. to 4 ft. 3 in. below the ground surface. Surface cover of living organic material is 3 to 9 in. in depth. Soils range from fluvioglacial gravels to glacial till (stoney, silty clays with varying amounts of organic material, with the fine-grained material deposits being of greater extent). The largest deposits of coarse-grained materials (sandy gravels) are found on the northern portion of the site on the lower terrace immediately north of Boot Lake. Granular deposits are also found along the east and north banks of Twin Lake and to a lesser extent on knolls south of Boot Lake. Finer grained soils (stoney silt clays) are found in the ridges and in the lower areas over the rest of the site area.

It must be emphasized that the new town will still be founded on permafrost. It would be impossible to find any site in the delta area that was not underlain by perennially frozen material. In the development of the new townsite, therefore, every necessary precaution against disturbing the general permafrost condition will have to be taken. The topographical relief of the new site, however, will facilitate all surface drainage arrangements. The glacial origin of the underlying soils will yield more satisfactory foundation conditions than at the old site, and should provide reasonable supplies of road building material and gravel. At the same time, the glacial character of the local soils almost inevitably means that some massive ground-ice (in the form of *ice-boulders* in the glacial till) is present beneath the site so that some eventual ground subsidence is to be expected.

The site is a beautiful one, especially in summer, and spreads over rolling hills that are enlivened with small lakes. From the site there is a striking view of the low-lying delta to the west. With the careful town planning that is intended for the new settlement, the Aklavik of the future should be as attractive physically as the old Aklavik was disappointing.

Conclusion

Despite all difficulties the survey team completed their main assignment by the scheduled date, their findings pointing to *East Three* as the most desirable site for the new Aklavik. The third author had the privilege of visiting all four sites, in the company of his fellow authors and of other members of the team, in late July 1954. Two weeks later, the sites were visited by the then Minister of Northern Affairs and National Resources and by Mr. R. G. Robertson, his Deputy Minister. This is believed to be one of the first occasions when the Federal Minister responsible for Northern Canada has been able to study in the field, and far to the north of the Arctic Circle, the facts upon which a major policy decision was to be based.

The results of the survey were reported to the Advisory Committee on Northern Development, of which Mr. Robertson is the Chairman. The Committee endorsed the selection of *East Three* as the location for the new Aklavik and on November 18, 1954 the Federal Cabinet, upon the recommendation of the Minister of Northern Affairs and National Resources, officially decided that the town of Aklavik should be moved to this new site. Responsibility for the vast amount of work which the implementing of this decision involved is being shared by the Department of Northern Affairs and National Resources and the Department of Public Works. Preliminary planning has been done; work is actively proceeding at the site. Within a few years the new town will be a reality gracing its fine new location.

The authors are indebted to all the members of the survey team not only for their good work in the field but for demonstrating so well what can be achieved by real team-work in the interests of the awakening North.

Appendix A

the Survey Team

Members	Representing
K. C. Berry	Department of Public Works
R. J. E. Brown	National Research Council (D.B.R.)
G. H. Johnston	National Research Council (D.B.R.)
J. A. Pihlainen	National Research Council (D.B.R.)
J. K. Fraser	Department of Mines and Technical Surveys (Geographical Branch)
E. J. Garrett	Department of Transport
J. W. Grainge	Department of National Health and Welfare
C. L. Merrill (Leader)	Department of Northern Affairs and National Resources

Advisory Members "ex-officio"

Lieut. P. Johnson	Royal Canadian Navy—Aklavik
W. O. D. Allison	Canadian Army (Signals)—Aklavik
Inspector W. G. Fraser	Royal Canadian Mounted Police—Aklavik

Local Aklavik Advisory Committee

Canon R. K. Gibson (Chairman)	Anglican Mission
Father A. Biname, O.M.I. (Secretary)	Roman Catholic Mission
Karl Gardlund	Trappers
Charles Smith	Eskimo
Rev. J. Sitichinli	Loucheux Indians
Inspector W. G. Fraser	Royal Canadian Mounted Police
S. M. Peffer	Local Traders
H. Figgures	Local Traders
F. Carmichael	Territorial Government
L. B. Post	Department of Northern Affairs and National Resources (Local Administration)

Appendix B

Survey Costs

Staff salaries	$13,000
Personnel transport: Ottawa to Aklavik (Return) Edmonton to Aklavik (Return)	3,500
Rations (Purchased locally: 1440 man days at $3 a day)	4,320
Helicopter service	20,000
Labour (local)	2,857
Services (local)	468
Rental of equipment (local)	1,200
Camp fuel, 615 gallons heating oil at $0.26	160
Fuel for boats, 1277 gallons at $0.34	434
Oil for boats, 55 gallons at $2.50	137
Freight for initial camp, 3,000 lb.	3,630
Freight for drill rig*, 2,000 lb.	2,000
	$51,706

*N.R.C. property so no rental charges

INDUSTRIAL USES FOR AN AUXILIARY LOW FREQUENCY SUPPLY

G. L. Tiley, *Application Engineer*
Mining, Petroleum and Chemical Division

E. Oldfield, *Application Engineer*
Mining, Petroleum and Chemical Division
Canadian Westinghouse Company Limited, Hamilton, Ont.

Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June, 1959.

THE A-C INDUCTION MOTOR is the simplest and cheapest electrical rotating machine for industrial drives and is ideally suited to constant speed applications. Pole changing may be used to obtain a two or three to one speed ratio, but for higher ratios it becomes impracticable and a wound rotor motor must be used. The well known speed-torque curves of a wound rotor motor (Fig. 1) and h.p. diagram (Fig. 2) point out its fundamental disadvantages, viz.

1) If torque is to be maintained reasonably constant between standstill and full speed, the amount of external secondary resistance in circuit must be varied over a wide range. This can be done either with a liquid rheostat or metallic grids and contactors.

2) It is wasteful of power. At 50% speed, say, half of the power supplied appears as heat in the secondary resistors.

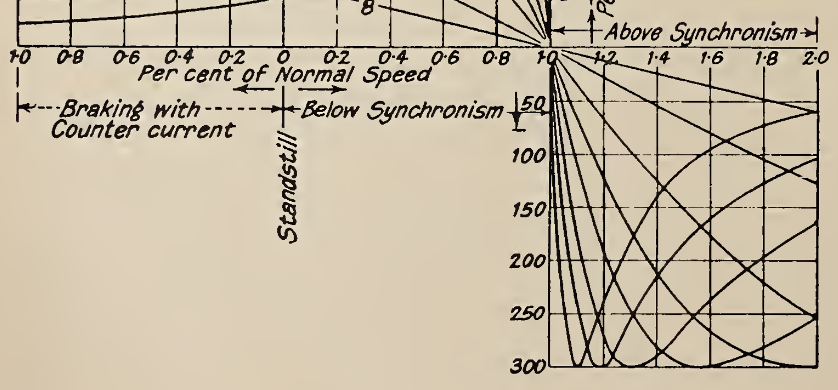
3) Regenerative torques, obtainable by reversing the stator supply, are not easy to control. Also, three times as much power is wasted in the secondary resistors as is usefully employed.

4) Accurate speed control at low speeds is very difficult, because the speed varies considerably with load in this region.

In addition to adjustable speed drives, there are many applications where two widely different speeds of operation are required — a very slow speed for creeping and a normal speed for running.

It is the purpose of this paper to show how an auxiliary low frequency a-c. supply can overcome some of the above mentioned drawbacks, thereby broadening the range over which the induction motor can be economically and satisfactorily applied in industry.

Fig. 1. Curves connecting speed and torque for several values of rotor resistance.



Low Frequency Equipment In The Rotor Circuit

The low frequency generator was originally developed for use in the rotor circuit of an induction motor. With such a scheme, the speed may be controlled at speeds near the synchronous and without the losses associated with secondary resistors. The power factor of the induction motor can also be controlled by injecting voltages of the correct frequency and phase angle into the rotor circuit.

Fig. 3 shows the schematic layout of the system, designed to give shunt characteristics to the drive, i.e. the speed of the induction motor will not vary greatly with load, but the set speed will be adjustable.

Field coils F are fed from taps of an auto transformer B, whose terminals are across the sliprings of the induction motor. The flux in this auto transformer remains constant at all slips, because when the voltage across the rings increases, the frequency in the rotor circuit increases at the same time. For a given setting of the taps the flux in the field coils F1, F2 and F3 will, for the same reason, be constant and independent of frequency. The amount of flux F1, F2 and F3 can, however, be adjusted by altering the position of the tappings.

The armature A of the low frequency generator is also connected across the sliprings through the compensating and interpole windings C and will always generate a back e.m.f. at the same frequency as the slipring frequency.

At speeds below synchronism the low frequency generator acts as a motor to drive the induction motor E at above its synchronous speed. Power taken from the rotor circuit is thus returned to the lines. Speed is controlled by adjusting the auto transformer taps.

The greater the speed range required, the higher will be the voltage and frequency to be handled by the low frequency generator. Economic considerations limit the speed range to about 15% below synchronism.

The addition of an ohmic drop exciter, which is nothing more than a frequency converter mounted on the shaft of the main induction motor, enables the speed to be taken above synchronism. In this case, power is fed into both the stator and rotor of the main induction motor.

Low Frequency Supply To The Stator

Recent developments in the application of low frequency equipment have been directed towards its use in the stator circuit of induction motors. This work has been pioneered in Germany, particularly for automatic mine hoist control. A brief description of some of these applications follows:

1) *Mine Hoists*—A typical production drum hoist duty cycle is shown in Fig. 4. The a-c. drive is considerably cheaper to install than the equivalent d-c. drive for horsepowers below about three thousand. Where the full speed time is long in comparison with the accelerating and decelerating times, running costs may also favour the use of an induction motor.

To maintain optimum duty cycles and accurate stopping, deceleration and creeping speeds must be consistent and independent of load. Prolonged operation at creep speed during shaft and rope inspection trips must not overheat the motor or the resistors.

Manually controlled a-c. hoists are in use all over the world, but usually the operator must use the mechanical brakes to "trim" the speed during deceleration and creeping. Often a shaft inspection trip must be interrupted while the rotor resistors cool off.

A semi-automatic hoist using a low frequency supply for braking and slow speed operation has recently been installed. Fig. 5 shows the speed torque curves obtained during tests on the 1250 h.p., 4160 volt hoist motor, when supplied with 60 and 4 cycles power and the rotor short-circuited. The proportional voltage at 4 cycles would be 4160/15-277 volts. It will be seen that for comparable performance the motoring voltage should be increased to 390 volts and the braking voltage reduced to 175.

When motoring on 4 cycles, maximum torque is developed at standstill with the rotor short-circuited. As rotor resistance is added, the torque falls away, as shown in Fig. 6.

Accurate control of braking torque is obtainable by adjusting the value of the rotor resistance at any speed. Moreover, shorting out steps of resistance by means of timed contactors as the speed falls, produces a certain amount of self correction of torque with load, in the same way that timed acceleration on 60 cycles tends to maintain constant acceleration, independent of the load. During automatic operation the hoist to which reference is made operates as follows:

Just before deceleration is due to commence, the power being taken by the hoist motor is measured. This gives an indication of the load in the skip. The deceleration programme is set up accordingly, so that when the skip reaches a certain position in the shaft, the normal frequency supply is removed and replaced by the low frequency supply at braking voltage. Simultaneously a pre-determined amount of rotor resistance is introduced. As the hoist decelerates, other contacts of the limit switch cut out rotor resistance. As the skip is about to enter the horns, the rotor is short-circuited and the low frequency voltage increased to the motoring voltage. Creep speed is maintained accurately, and independent of skip loading, by virtue of the "stiff" speed torque characteristics obtained once the slip rings are shorted.

Low frequency is also used for manoeuvring and for shaft inspection runs. Under these conditions no power is dissipated in the rotor resistors. The frequency of the supply is chosen to give the desired creep speed. In the case under discussion, either three or four cycles may be selected manually on a two speed gear box.

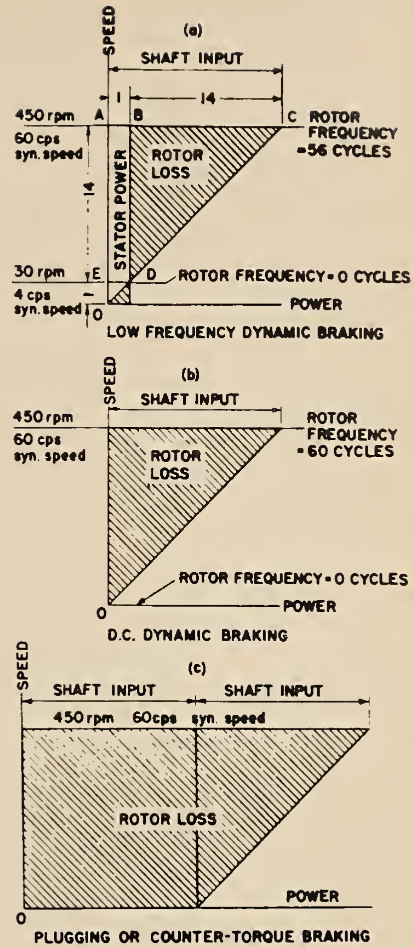


Fig. 2. Power and energy relations during braking.

2) *Use of Low Frequency for Starting and Barring of Ball, Tube and Rod Mills*—The torque required to start rotation of a ball, tube or rod mill is relatively high when compared with the running torque. The reasons for this high starting torque requirement are:

1) Friction is high until such time as an oil film has been established under the bearing journals by rotation.

2) If the mill is stopped without first emptying the charge the material will settle and harden, and the torque required to rotate the drum and its out-of-balance load is high until the point is reached at which the load starts to cascade and break up. Once the load has been broken up by cascading, the mill can be stopped and if started up again soon enough there-

after, a much lower starting torque will be required.

Starting presents no great problem when wound rotor induction motors are used, as the rotor resistance can be adjusted to give maximum torque at standstill, and then reduced progressively as the mill speeds up.

If synchronous or squirrel cage motors are used, however, they must have a high starting torque for the reasons given above. They must also deliver high torques in the neighbourhood of full speed; the synchronous motor must be able to pull the high inertia mill into synchronism and the squirrel cage motor must run at low slips to be efficient. These two requirements are mutually incompatible and, in practice, it is necessary to use a motor about 40% larger in size than is actually required for continuous running.

The motor can be of smaller size if a slip coupling of suitable rating is interposed between the motor and the mill, but such couplings are relatively expensive and introduce continuous losses while running.

An auxiliary low frequency supply can be used to advantage in reducing starting torques, as will now be explained. One set of low frequency equipment may be used to start a number of mills if arrangements are made to start only one mill at a time. Each mill will have two starters, one connected to the main and the other to the low frequency bus.

When the low frequency contactor is closed, the motor will develop practically maximum available torque on low frequency at standstill as illustrated in Fig. 6 and the mill will start to rotate. If a synchronous motor is employed, the synchronizing relay will operate almost immediately to apply the field as it is usually set to detect a rotor frequency of about 3 cycles/sec. The motor will then continue to rotate with full available torque as a synchronous machine.

Tests on a typical synchronous motor driving a ball mill gave the following figures:

- Starting Inrush on 2200 V, 60 cycles—1100 amperes
- Starting Inrush on 175 V, 4 cycles —350 amperes
- Full load current at 2200 V, 60 cycles—200 amperes
- Running current on 175 V, 4 cycles —160 amperes

A mill can thus be barred over at low frequency and run until the bearings are lubricated, and the charge is broken up. It will then start very easily if immediately switched over to normal frequency.

In an alternative method of operation, the low frequency power is applied to rotate the mill in the re-reverse of its normal direction of rotation. When transferring to normal frequency in the correct direction, the out-of-balance load will assist the mill to get up to speed, and so further reduce the required starting torque.

The low frequency supply is also used for turning the mill over slowly during maintenance operations. Very accurate spotting is possible and the stresses caused by the high starting inrush current on normal frequency are eliminated.

3) *The Use of Secondary Reactors with Low Frequency*—The use of resistors and reactors in the rotor circuit of an induction motor can produce some interesting results.

This system has recently received much attention, chiefly because computers are now available to the design engineer. Previously, the ultimate performance of an induction motor with resistor-reactor secondary control could only be predicted after many hours of tedious slide rule computations. The expense of engineering was an economic deterrent.

Fig. 7a illustrates how a substantially constant torque may be achieved between standstill and full speed by the judicious use of reactors and resistors with only two secondary contactors, when a motor is supplied with 60 cycles.

With low frequency supplied to the same machine, the dynamic braking characteristics for any particular value of applied voltage will similarly be essentially flat, as shown in Fig. 7b. It now becomes practicable to control the rotor circuit automatically, by means of one- or two-speed, or frequency-sensitive switches, and still maintain the torque constant within a few percent between standstill and full speed.

To control the torque, it is only necessary to vary the voltage applied to the stator.

Fig. 8 shows a system developed for controlling a mine hoist by this means. A variable voltage, low frequency supply is generated by a fre-

Fig. 3. Low frequency M.G. set.

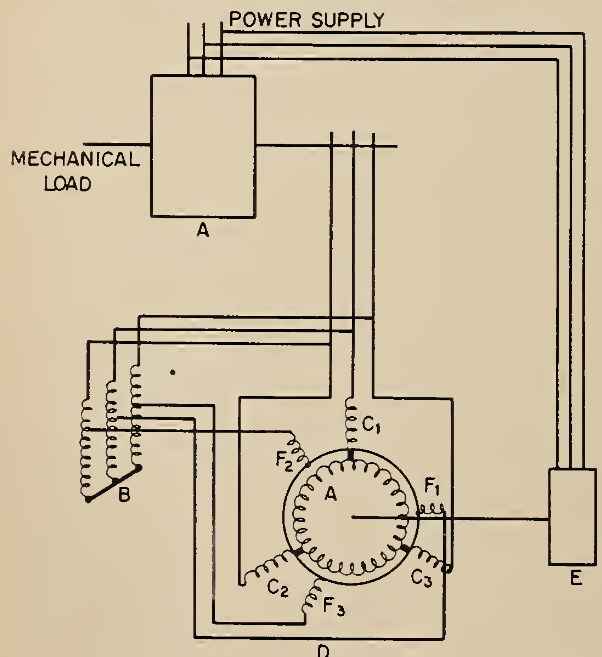
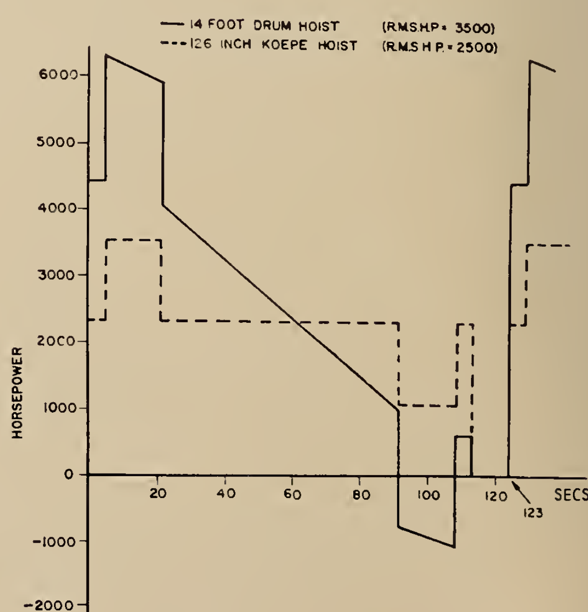


Fig. 4. Drums hoist duty cycle.



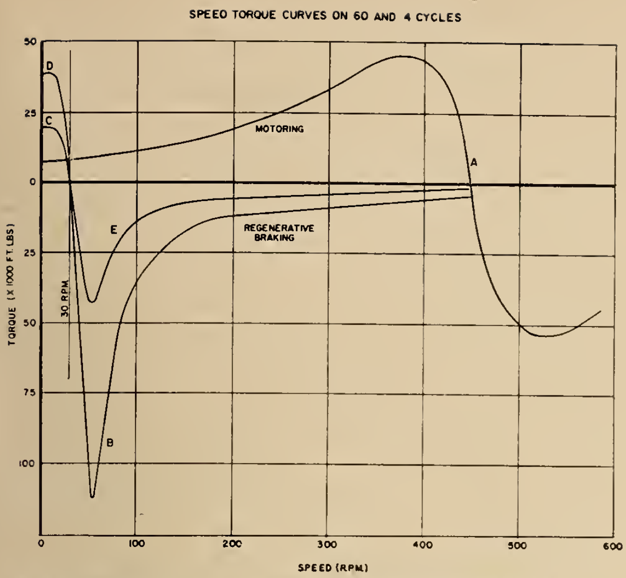


Fig. 5. Speed torque curves (zero external resistance): (A) 4160 volts 60 cycles; (B) 277 volts 4 cycles braking; (C) 277 volts 4 cycles motoring; (D) 390 volts 4 cycles motoring; (E) 175 volts 4 cycles braking.

Fig. 6. Speed/torque curves—induction motor 4 cycle motoring.

quency changer that is fed from a small alternator mounted on the same mg. set. This mg. set may be driven by a standard squirrel cage induction motor because the slip frequency is determined primarily by the gear box ratio and not by the speed of the set. The size of the hoist motor necessitates the use of a low frequency mg. set.

Provided the duty cycle always calls for braking torques during the decelerating period, this system gives stepless control of deceleration and creeping speeds. At the beginning of the deceleration cycle, the normal frequency supply to the motor stator is replaced by a low frequency supply of the same phase rotation. At the same time, a secondary contactor closes to introduce the reactors and an auxiliary contact completes the circuit to the alternator field.

The alternator voltage is now a function of the speed-error signal and controls the braking torque in such a manner as to keep the hoist to the preset speed program down to creep speed. When creep speed is reached, the rotor is automatically short-circuited and the low frequency voltage increased.

Use Of Low Frequency For Anodizing Aluminum

An interesting and rather unusual application of low frequency was recently investigated. This concerned the anodizing of aluminum. Anodizing may be defined as the electrochemical conversion of the surface of aluminum to aluminum oxide, the aluminum serving as an anode in an aqueous electrolyte and the oxygen being provided by the electrolytic dissociation of water.

The aluminum oxide film is extremely hard and is highly resistant to corrosion and wear. Attempts to produce a thick anodized coating by conventional d-c. electrolysis however, resulted in a high percentage of rejections due to "burning".

The oxide film has a high specific resistance so high voltages have to be used when thick layers are required. "Burning' occurs when a local weakness of the film results in the concentration of current at that point. The resultant heating causes the film to break down and "burning", or local melting, takes place almost instantaneously.

It was found that periodic current reversal reduced the occurrence of burning by producing a more homogeneous surface film.

One method of current reversal involves the use of reversing contactors with a d-c. supply source. In another method, reversal of current is effected by injecting a-c. at mains frequency into the d-c. supply. This system requires the use of enormous capacitors and chokes to isolate the two supplies. Both of these methods become expensive when large powers have to be handled.

A standard d-c. generator will satisfactorily commutate frequencies up to 3 or 4 cycles and it was also found that the frequency changer commutator could handle a d-c. component. Two standard machines connected in series have been used to produce a d-c. supply that can be modulated to effect periodical reversal of polarity.

Performance of a pilot installation has been excellent. It was primarily intended for hard anodizing of high copper aluminum alloy components for aircraft. The high copper content had prohibited the use of conventional d-c., and the parts had previously been shipped to Great Britain for processing in a mains frequency-modulated system. The use of low frequency modulated d-c. now permits these alloys to be anodized locally and much more economically.

Standard anodizing process times were cut by as much 60%, proving the value of a low frequency supply in commercial anodizing.

Low Frequency Generating Equipment

Very expensive, low speed machines would be required if a frequency of 3-5 cycles per second were to be generated by conventional alternators. If a commutator is used, the speed of rotation can be much higher than the output frequency and economical machines are possible.

There are two main types of low frequency generating machines, i.e.

a) Frequency Converters
b) Low Frequency Generators

In general, frequency converters can be used in those applications requiring less than 20 kw. and less than 100 volts, and low frequency generators are required for higher powers.

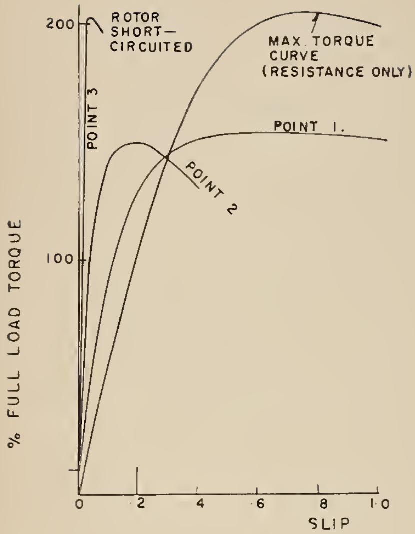
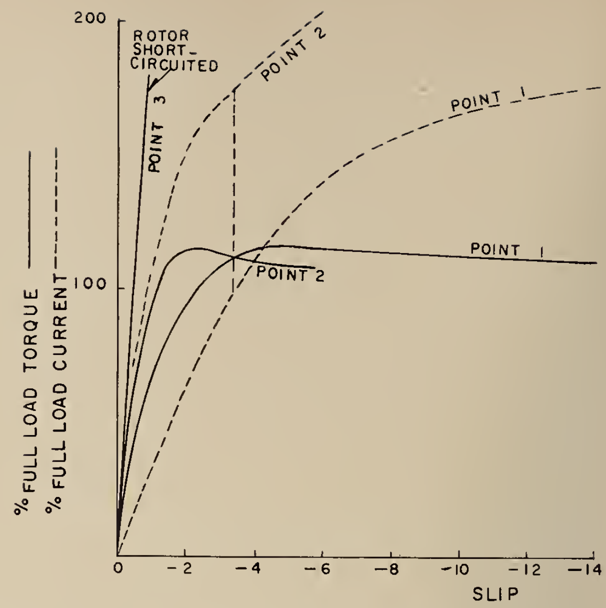


Fig. 7(a). left — Speed/torque curves — induction motor — 60 cycle motoring resistor — reactor rotor control.

Fig. 7(b). right — Speed/torque curves — induction motor — 4 cycle dynamic braking resistor — reactor rotor control.



The design and peformance of these machines has already been described in detail in several papers, and only a brief outline will be attempted here.

1) *Low Frequency Converters*—Consider an ordinary 2 pole d-c. armature, provided with a commutator at one end and three sliprings tapped into the winding at three equally spaced points at the other. Let the armature at first be stationary, and let the rings be fed with 3 phase currents at 60 cycles. The currents will produce a magnetic field revolving anticlockwise, let us say, looking at the commutator end, at a speed of 3600 r.p.m. This will set up a back e.m.f. to balance the e.m.f. of the supply. The flow of current will be limited mainly by inductance of the winding and it will lag behind the applied e.m.f. If there are three brushes spaced 120° apart on the commutator, the voltage between these will alternate at 60 cycles and will have the same virtual value as on the rings.

Now, make the armature rotate in a direction opposite to the magnetic field. The speed of the field relative to the tappings remains the same, i.e. 3600 r.p.m., but the speed relative to the stationary brushes becomes less and less as the speed increases up to 3600 r.p.m. The value of voltage across the brushes remains the same, but the frequency decreases.

At 3600 r.p.m., the field becomes stationary relative to the brushes which have a steady voltage across them. The machine is then a synchronous converter and may be used to yield d-c. current from an a-c. supply.

At speeds either above or below synchronism, the apparatus operates as a frequency converter, yielding at the brushes a frequency that is the difference between the frequency of the supply and the frequency of rotation. *(Continued on page 68)*

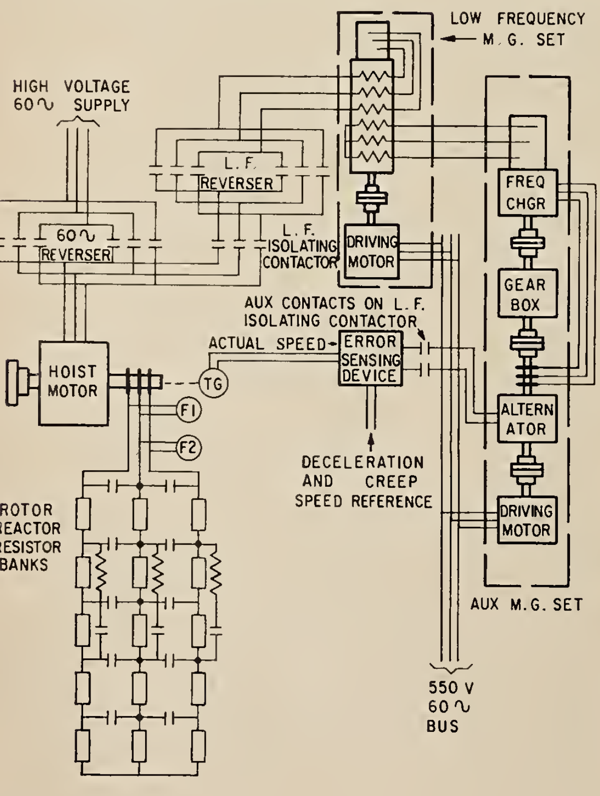
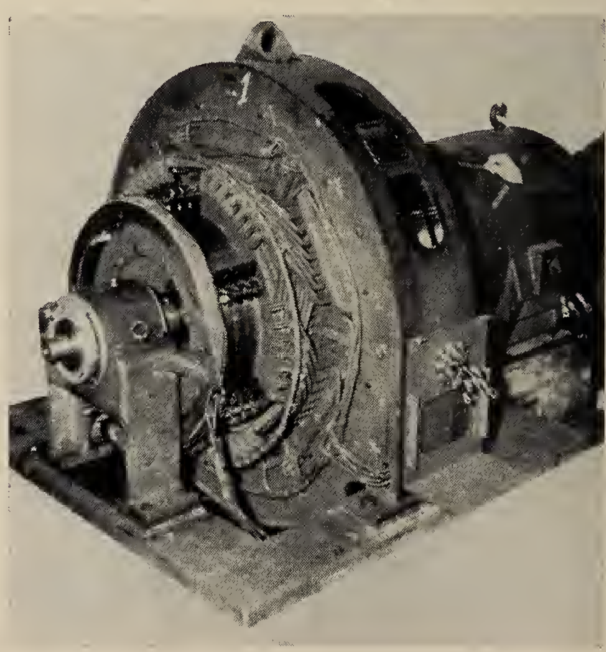


Fig. 8. left—Schematic diagram of hoist control using regulated voltage low frequency for dynamic braking and creeping.

Fig. 9. below—Scherbius generator.



RIVER CONTROL IN THE INTERNATIONAL RAPIDS SECTION THE ST. LAWRENCE POWER PROJECT

K. A. Henry, Jr.E.I.C., *River Control Engineer*

The Hydro-Electric Power Commission of Ontario

Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June, 1959.

The paper describes the rather unusual circumstances which arose in the International Rapids Section during construction of the St. Lawrence Power Project, where numerous agencies and their many contractors all were engaged in works affecting river conditions. The need for an all-embracing control of operations affecting river conditions, and the administrative arrangements for this unification, are outlined. The actual field control system and the necessity for continued use of models in construction as well as design are shown by describing how some of the more interesting problems were handled.

The Need for a River Control System

THE ST. LAWRENCE POWER PROJECT and associated Seaway work in the International Rapids section of the St. Lawrence River between Cornwall and Prescott presented an exceedingly complex construction problem. From the beginning the power entities, Ontario Hydro and the Power Authority of the State of New York, as well as the two seaway groups, Canada's St. Lawrence Seaway Authority and the United States Seaway Development Corporation, were all at work on the same reach of river and were continually faced with the possibility of adversely affecting each other's working conditions. Also the Order of Approval by the International Joint Commission for construction of the Power Project required that the construction proceed without adversely affecting upstream or downstream conditions, which in effect meant that Lake Ontario levels and St. Lawrence flows must be maintained in accord with the levels which would have occurred had no project been built, as well as requiring maintenance of satisfactory navigation conditions for the existing 14 ft. draft shipping.

Engineers of the power entities, using both topographic and structural hydraulic models as the chief tool, started from studies and reports dating back many years, and evolved a basic design for the International Rapids section. Once the basic design was settled, a working sequence was determined and from these two bases a series of contracts were developed, of which the starting and finishing dates were vitally interlocked.

It was readily apparent from the early stages of planning that to comply with the Order of Approval would require some unified control of operations affecting the river. In April 1955 at a meeting in Montreal, The St. Lawrence River Joint Board of Engineers, appointed by the governments of Canada and the United States to supervise the project for the Federal governments during the construction period, expressed concern over this feature. It was then learned that the Power Entities proposed to prepare and submit for approval an overall method of River Control. This method would outline all the steps in the construction procedure which might affect the river regimen. To ensure proper implementation of this plan a River Control Engineer, familiar with the work and planning, would be appointed and placed on the site to advise the Project Director for Ontario Hydro and the Project Manager for the consultants to the Power Authority, on all matters pertaining to levels, flows, currents and navigation. This then was the background for the creation of River Control and the author was appointed River Control Engineer in the spring of 1955, following several years of work on the planning stages of the project at the Hydraulic Model Laboratory in Toronto.

Fig. 1.

The conception of a St. Lawrence Power Project in the International Rapids area probably dates back as far as the beginning of hydro-electric generation. Certainly when the last barriers to construction were removed in 1953, designers had a wealth of earlier studies to draw from. Starting from these original conceptions and using new design techniques, particularly hydraulic models, they completed hydraulic design for the combined shipping and power channels.

In all the design work, one of the more fundamental considerations was the sequence and method of work to ensure that no material change in river flows or Lake Ontario levels would occur and that the existing 14-ft. draft navigation could continue uninterrupted. It was no easy matter to produce such a sequence under the simplest of construction concepts, but when the work was finally divided amongst the four responsible agencies, and each had divided its share into manageable sections for the calling of contracts, a vastly complicated pattern of starting and finishing dates for the contracts arose. Nearly all the work depended on river diversions and cofferdamming operations. It was essential that the effects of work by different contractors balance one another producing as small a total change as possible. This required a close, comprehensive system of control. Also essential was a comprehensive inspection of work progress and continual measurement of effects of work and operation of control structures on the critical aspects of river regimen and navigation. As the job progressed this measurement of effect became more important, since the natural controls of the river were eventually completely removed and replaced by man-made and man-operated structures.

The concern of this paper will be with the system of inspection, measurement and control used to ensure the high degree of co-ordination and co-operation that was essential.

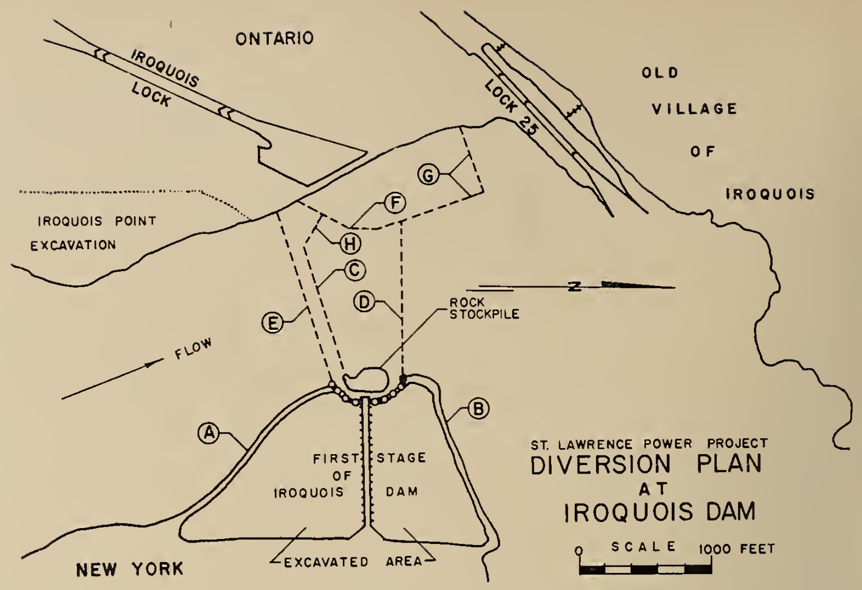


Fig. 2.

The Gathering of River Control Data

To keep track of what is happening in a river, the most readily available measurement is that of water levels. For this purpose, prior to the construction period, the power entities established a series of more than thirty continuously recording gauges, in consultation with, and to the satisfaction of, the governmental supervising agencies concerned. The locations of these are shown in Fig. 1. Some of the gauges were duplicates of long established measuring points but most of them were new. Analysis of the levels at these points made possible the determination of construction effects in the whole reach. Use could be made of the services of a large and expert hydraulic surveying crew from Ontario Hydro, equipped for precise current metering and accurate echo sounding, with all the necessary radio communication for rapid determination of flow conditions other than levels.

Also available, of course, was all the information from the very co-operative field engineering services of the consultants and of Ontario Hydro, as to progress by the various contractors and predictions of the likely course and rate of construction.

From the beginning it was evident that gauge records collected and tabulated once a week would not provide the necessary data for control of operations quickly enough. As work progressed, the need for quicker reporting of conditions would become more urgent. Therefore, certain critical gauge levels were telemetered, via standard telephone service, to control centres. At first, since work at the two ends of the project was generally unconnected, two separate centres were used, one at the east end of the area and one at the west end; but as the work progressed and became more closely integrated and as operation of the river became more artificial, a single central control with a sub-centre was set up. Five of the six gauges telemetered to the Cornwall Control Centre are indicated in Fig. 1. The sixth gauge was located some eighty miles west of Prescott, at Kingston on Lake Ontario. The gauge at Massena Intake was only available at the Massena sub-centre, where the Dickinson Landing and South Shore gauges were repeated.

In order to provide a flexible and reliable means of emergency communication, a radio network was set up with four fixed stations as indicated in Fig. 1. There were also four radio-equipped vehicles, two working out of Massena sub-center, one from Cornwall and one from the North Channel Office. The fixed stations could all reach each other, while the mobile sets had a sure range of some thirty miles. In addition, a number of portable battery sets with ranges from one to ten miles, normally used for survey co-ordination, could be diverted to control use when required.

This, then, with the men to operate and service it, was the equipment used for river control.

The Procedure for Construction Problems

At first all the problems were in connection with the construction work. Contractors changed their methods of operation or the engineers varied the locations of channels. Every variation in scheduling, for these or any other reason, involved a whole chain of subordinate effects, so throughout the length of the river and for all the construction period, a constant series of changes and improvisations had to be evaluated and co-ordinated.

Project Directors were, of course, responsible for prosecuting the work. In cases where variations from the specified plans might affect the river in any way other than that planned initially, the variation was referred by the Director concerned to the River Control Engineer. The River Control Engineer reviewed the proposal and passed it on to the Hydraulic Engineer for evaluation, at the same time bringing the matter to the attention of the St. Lawrence River Joint Board of Engineers, and, if it could in any way affect navigation, the appropriate Department of Transport agency. After review by everyone concerned, if any appreciable change in overall effects appeared likely, the proposal, often in modified form, was submitted to the Joint Board of Engineers for approval, and upon approval was incorporated into the construction sequence.

There were of course many variations in the size and importance of the changes, from those conceived, presented, evaluated, approved and completed in a day, to others requiring months of model testing and formal submission for approval, affecting the whole construction procedure.

Construction operations were planned in as much detail as possible ahead of time, but naturally a good deal of the final timing depended on work progress. Such operations as the diversion of the river from its course to the man-made channels and control structures at Iroquois Dam and Long Sault Dam were of this nature, and control of them was accomplished through the River Control system.

The Procedure for Operational Problems

As work progressed, the river gradually became more and more artificially controlled. The artificial reproduction of natural conditions was a continually growing part of river control throughout the job. 'Natural conditions' is a rather difficult term to define, and it is evident that the reproduction of a damaging storm-bred seiche would not be at all desirable from any point of view. Proper modification of natural phenomena to improve the conditions for everyone in the river was inevitable. The operation of control structures to provide these modified natural conditions was carried out from the River Control Centre at Cornwall with operation orders to contractors and structures controlled by the consultants being transmitted through the Massena sub-centre.

Under artificial control, the river required continual surveillance at a period long prior to establishment of a proper operating staff on round-the-clock duty. This surveillance was obtained by painting directly on the visual record telemeter charts colored areas depicting dangerous levels or conditions. The security patrol on its hourly rounds checked each gauge and called the engineer on duty if anything appeared to be amiss. This economical system worked satisfactorily for over a year until the plant operators appeared on the scene.

The River Control system as described above worked satisfactorily throughout the construction period, culminating in the filling of the forebay to create Lake St. Lawrence in July of 1958 when, with greatly increased equipment and personnel, the system served as the basic method of control for that complex operation. The gradual switch in emphasis from control of construction operations to straight operation of a power plant is now nearly complete, but the basic system will always continue in operation.

Fig. 3. Iroquois dam just before flooding of first stage (October 11, 1956).

A Construction Problem — Diversion at Iroquois

A rather complex operation, in the fall of 1956, the diversion of the river at the site of Iroquois Dam from its natural course to the completed first half of the Dam, affords a good example of the type of construction problem which required the exercise of River Control facilities.

Construction of Stage 1 of the dam had been completed early in October. On October 22 the area was flooded and the diversion began. The map in Fig. 2 indicates the items of work mentioned below while Fig. 3 and 4 show the area at the beginning and end of the diversion.

The diversion plan consisted of the following steps:

1. Remove cofferdams A & B
2. Construct rock groin C
3. Construct earth fill F with rock kick dyke H for protection if needed.
4. Complete cofferdams D & E and unwater.

If it had been possible to work the above steps in sequence no problems would have been presented, but the exigencies of a very tight schedule compelled the contractor to overlap the steps so that in fact all were under way at once.

The factor controlling the rate of diversion was the removal of cofferdams A and B to provide new area for flow. Gates in the dam could, of course, readily be opened to accommodate diverted water. As quickly as new area for flow could be provided, the rock groin C was to be extended, until a closure against H was effected, whereupon the second stage cofferdams E and D could be completed. Throughout the operation flows of just under 250,000 c.f.s. were handled, but in view of the possibility of seiches it was necessary to be prepared at all times to handle 300,000 c.f.s.

Rock groin C, the primary closing structure, was built of rock excavated in Stage 1 and stockpiled for this purpose. It was a straightforward end dumping proposition, necessary because the construction of the final cellular cofferdam, E, in the swift currents which would be encountered was impossible.

A large number of factors, some of which are listed below, made necessary the most rigid control of every part of the work:

1) It was desired that as little raising of levels as possible occur upstream because part of such a rise would be transmitted right up the river, reducing flows from Lake Ontario. The local raising effect was

measured at a gauge about a mile upstream;

2) It was essential, in view of the near-capacity operation of the existing canal system, that the downstream navigation be carried through the river channel as long as possible with as little velocity change as possible and no lowering of levels;

3) No excessive drop in levels through the work area could be tolerated because the associated high velocities might cause wash to occur at cofferdams A or B with the material being deposited in areas where excavation was complete. Also, dyke F was built of dumped till and no increase in velocities could be tolerated, because even under the best balanced conditions velocities of 12 ft. per second along the exposed side were expected;

4) It was quite easy for an excessive drop to be created because the contractor had available sizeable stone for the rock groin C and could push this out to cut off more flow area than had been excavated at cofferdams A & B;

5) The approach to Lock 25 from downstream had always been difficult in the fast current and the moving of the whole river to a new location changed the currents considerably so that a varying effect was felt. The high velocity jet from increased head drop would aggravate this effect.

In the summer of 1956 the contractor and engineers had collaborated in extensive model studies to determine the best balanced conditions satisfying the strict criteria of proper functioning and limited time. As a result of these studies, the contractor was made aware of the items likely to limit his progress.

The method of control adopted for the operation was to limit the length of the rock groin C and the gate openings in the completed first half of the dam. The contractors were all allowed to press work as quickly as possible in all other items. A careful check was kept on the stage upstream and no appreciable increase above normal was permitted. As velocities built up along dyke F with the approach of rock groin C some material was washed away, but a closure was effected in mid-December.

Some difficulties in navigation arose, but careful arrangement of gate openings according to improvements noted by the ship captains allowed navigation to continue uninterrupted.

This brief description of a rather straightforward problem affords an illustration of the construction end of river control.

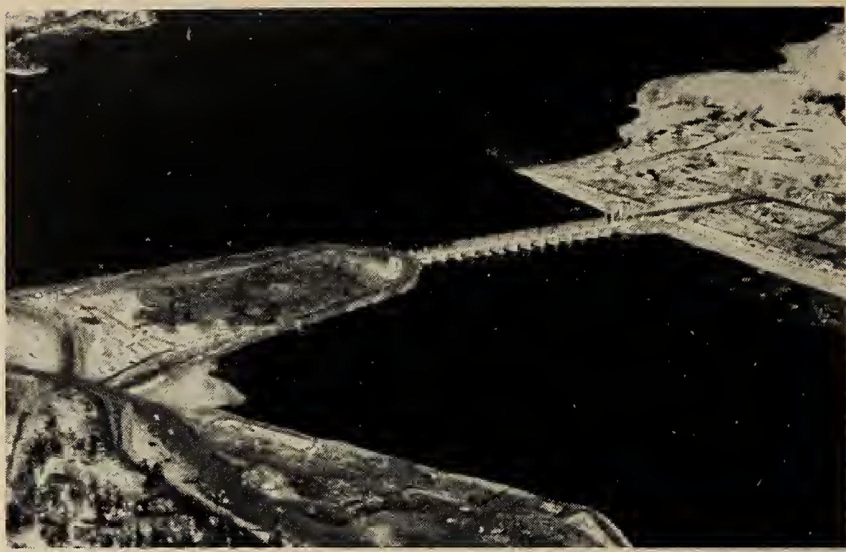


Fig. 4. Iroquois dam with cofferdams for second stage complete (February 5, 1957).

Operational Control of Seiches

Any description of the normal operation of control structures to produce the desired modified natural conditions in the river would make singularly unexciting reading. The feature of this part of river control which did cause some excitement on occasion was the operational procedure during seiches.

Seiches themselves are an interesting phenomenon in the St. Lawrence River, the word itself being mysterious enough to alarm the uninitiated. The St. Lawrence is normally considered to be a very stable river, and so it is. Many rivers can quickly increase their flow by two or three times and often much more. A change of 20% in the St. Lawrence is abnormal, and a good thing it is, too, when it is realized that even this represents something like forty to fifty thousand c.f.s. A good example of such a change happened on November 17, 1955, when the flow, which had been averaging some 255,000 c.f.s. rose to 293,000 c.f.s. for a day, and was actually well over 300,000 c.f.s. for some hours. This type of phenomenon is known as a positive seiche.

Observations so far have indicated that seiches are always linked to weather disturbances. In general, south-west winds pile water up at the east end of Lake Ontario spilling extra water into the St. Lawrence River, and as the extra water passes down into the more constricted sections, the rise in level increases. Negative seiches occur under the influence of northeast winds. The seiches seem to be linked also to barometric pressure differences and sometimes occur without too much wind.

Under artificial control conditions with the gates at Iroquois Dam set partly open, as they had to be through the summer of 1957 on account of navigation conditions at Lock 25 just downstream of the Dam, the gates were, in effect, orifices, and the rise in Lake Ontario at Kingston might be exaggerated as much as four times just upstream of the Dam. Additionally, as mentioned previously, it was not in the best interests of all concerned to pass a seiche downstream. For flood routing the storage had to take place above Iroquois Dam, causing an exaggerated rise in levels. A seiche might of course be too large to be routed, and the hazard of starting a routing program and then having to let go was that downstream conditions might worsen.

The most effective defense against seiches is an efficient warning service. This should provide two items of information: primarily, notice that a seiche is imminent; and secondarily, the size of the seiche.

The Ontario Hydro has developed a weather watching section to assist operation of the Niagara plants where the large Lake Erie level variations affect flows drastically. Because St. Lawrence River seiches are dependent on large scale weather systems and not on local weather, a minor extension of the standard watching procedure has provided warning of serious seiches. On the other hand, it has not been possible so far to invariably distinguish between disturbances which will cause a sizeable seiche and others which have very little effect.

In general the first warning of a

seiche comes from the Hydro's Toronto weather centre. Once an alert has been given the next indication shows up on the local barograph. Seriousness of seiches is usually indicated by the lowness of pressure, the steepness of the drop and duration of the minimum pressure. The Kingston telemeter shows the actual beginning of the seiche, and here again size is indicated by the rate of rise, the height of rise and the duration of the elevated levels. In general, fast short term rises dissipate rather quickly, while the slow long-lasting rises multiply as they come into the project area. The height of rise is of course directly related to the seriousness of the seiche.

Let us look at a particular case. At noon, Friday, November 8, 1957, a warning was received from Toronto that all necessary conditions preliminary to a seiche existed. This confirmed the indications of a steeply falling barometer, which at that moment stood at 29.62 in. The barometer continued falling till a low of 29.29 was reached at eight o'clock p.m. Meanwhile a small rise in level occurred at Kingston between three and four o'clock in the afternoon, which seemed unlikely to cause trouble. The continued barometric drop indicated that there might be more to come, and indeed, between eight and eleven p.m., the level at Kingston rose to a foot above normal. It was decided that this seiche would be too large to route, so orders for opening three gates at Iroquois Dam were given at eleven o'clock, which stopped further rise above the dam.

However, the level at Iroquois Dam did rise over 3 ft., approaching very closely the maximum permissible height at certain construction sites. The flow, which had been averaging some 220,000 c.f.s., was allowed to increase to 250,000 c.f.s. by the opening at Iroquois. Downstream at Long Sault Dam, matching changes in gate settings were required to prevent damage because at this point a rise of a foot would have exceeded the maximum permissible level at the Cornwall Canal Locks. Further gate openings were required on Saturday but by Sunday afternoon everything could be returned to normal.

This seiche was typical of a dozen or more which occur each year, and which will continue to be a feature of the operation of control structures in the upper St. Lawrence River. Creation of Lake St. Lawrence in the summer of 1958 has made it possible to route larger seiches and increased operating experience is gradually making the control of levels and flows more precise.

The Creation of Lake St. Lawrence

The creation of Lake St. Lawrence took place from July 1 to July 3, 1958 and this complicated operation, the culmination of three years of intense construction effort, called for a great temporary elaboration and amplification of the River Control System.

Toward the end of June all the necessary clean-up work possible was completed in the area to be flooded. Long Sault Dam was substantially complete and ready to act as the valve for controlling flow out of the pool while Iroquois Dam was ready to control the inflow. All dykes and other structures were completed and awaiting the rise of water. The powerhouse itself was ready to be flooded, but the upstream cofferdam was still in place and had to remain so because its removal would cause flooding of the 14 ft. canal near the powerhouse. Navigation had continued uninterrupted up to this time, passing up and down the canals and locks as usual, slipping through the Cornwall dyke by means of a 50 ft. wide concrete slot known as the Closure Structure. The new locks, which were to lift shipping from Lake St. Francis into the new lake, stood ready.

The flooding procedure consisted first of all of clearing the reach of all ships, closing the hole through the dyke at the Closure Structure and clearing out the last-minute power and telephone lines and canal fixtures. Then with everything ready, the upstream cofferdam was to be removed by blasting and erosion, inflow to the pool was to be increased, the outflow reduced and the level raised. Every effort was made to reduce the time of the operation to the absolute minimum in order to have as little delay to shipping as possible, and so the various items overlapped, making rigid adherence to a very careful schedule essential.

The operation was carried out under the direction of the Project Directors; the river control system provided the necessary data, analysis and communications to make this direction effective.

A Central Control Room was established where all data was collected by radio, telephone or telemeter. A staff of three men well versed in the required work was on hand round-the-clock to process the data, and the Project Directors or their responsible agents were continually present or immediately available. It would be overambitious to attempt to describe all the changes in the gauging system needed during this period. Many gauges were removed just prior to flooding and new gauges were ready to go into action when the water reached them. At telemeter sites where information was needed continuously, staff gauges with readers radioing information were used until the level climbed to the waiting new installations. In case of telemeter failures, standby telephone communication and radio sets were on hand. Because of the large numbers of people in the area, a helicopter was kept ready to ensure that emergency transportation needs would not be interrupted by traffic snarls. For the transmission of orders for gate operations, direct telephone lines were set up with standby telephone arrangements and a radio link as a third line if needed.

The plan for the flooding operation was governed by two principal features. The rate at which water could be impounded was limited because upstream considerations imposed a maximum on the rate of inflow and downstream considerations made necessary certain minimum outflows. The necessity of providing 14 ft. draft navigation facilities right up to the last possible minute before flooding meant that the old locks must be left substantially unimpaired and that some power and telephone lines in the area to be flooded had to be maintained.

After nearly six months of planning and co-ordination between the power entities and navigation interests, a plan was settled on. All planning was done to an H-hour which eventually was set at 4 a.m. on July 1, 1958. At this critical time, the gates at Iroquois Dam were to be opened to let in extra water thereby beginning the actual filling of the pool. Events occurred in about the following sequence:

1) At 4 a.m. June 30, shipping was stopped from entering the area to be flooded, and by about noon the reach was clear.

2) Shortly after dawn on June 30, removal of power lines to locks and telephone lines started; it was finished well before flooding took place.

3) Dismantling of the lock equipment began as soon as shipping cleared the various locks, and was completed in good time ahead of flooding.

4) When the last ship had cleared the Closure Structure in the Cornwall Dyke, the steel stop logs were set in place completing the last plug in the pool except for the Long Sault Dam.

5) At July 1, the Iroquois Dam was opened and a total of some 310,000 c.f.s. began to spill in the pool.

6) At 7 a.m. the first port at Long Sault Dam was closed reducing the outflow to about 220,000 c.f.s.

7) At 8 a.m. after construction crews had left the danger area and the Provincial Police had made sure that no one else was too near, the upstream cofferdam at the powerhouse was blasted and within a short time the water had removed a large part of this earth structure, at the same time beginning to fill the pool just above the powerhouse.

From this time on the hydraulic features of the flooding governed all operations. As the water level rose, ports were closed at Long Sault Dam to produce a reasonably constant flow downstream. When the level reached the sills of the permanent sluices, water was spilled there too, until after closing all the ports some of the sluiceways were also closed bringing the water up to its final level. At Iroquois Dam, as the tailwater rose, more gates were opened to maintain the high flow to the pool until flooding was complete, when the gates were set to pass the natural flow of the river.

In the Central Control Room, the numerous gauge levels gathered there were used to compute the flows and flooding progress every few minutes. This progress was constantly compared with the planned rate, and at the appropriate times orders were despatched for gate movements to Iroquois Dam and to Long Sault Dam via the consultant's offices at Massena.

On July 2, both the Canadian and United States powerhouses began to use water for turning generating units. On July 3, navigation authorities began the placement of new aids to navigation in the new channels and on July 4, the mass of shipping tied up during the flooding began to move through the new facilities.

It is with no small amount of admiration that the author takes this opportunity to pay tribute to the splendid spirit of co-operation between Power and Seaway entities and between Canadian and United States engineers which made the job a success.

INDUSTRIAL USES FOR AN AUXILIARY LOW FREQUENCY SUPPLY

(Continued from page 62)

It should be noted that no stator is necessary. In practice, the armature is surrounded by a laminated iron stator in order to decrease the magnetizing current required.

The 4 pole armature is driven through a reducing gear box by an 1800 r.p.m. reluctance type synchronous motor. This motor has only to supply friction and windage losses. The commutator is provided with 6 sets of brushes. If the gear is 1800/1710 r.p.m. the output frequency will be 3 cycles. For 4 cycle output, the required gear ratio is 1800/1680 r.p.m. In the frequency converter a manual changeover allows either frequency to be selected.

Commutation limited the output of the machine illustrated to about 35 volts, 4 cycles. On test, sparking was found to be a function of voltage rather than current i.e. it was caused by the voltage induced by the rotating field in the coil sides being commutated. The maximum output was raised to about 55 volts by machining axial slots in the stator: these slots were spaced so that they were opposite the coil sides being commutated, and so reduced the flux at these points.

An alternative design of frequency converter has a similar rotor. A 3 phase winding is added to the stator, and the stator leads are connected through resistors. The machine then behaves like a wound rotor induction motor turned inside out, and is self-driven. Sixty cycle power is fed to the slip rings and slip frequency appears at the brushes. However, such a machine is very sensitive to changes in the supply voltage. Stability may be improved by artificially loading the armature with a fan or a brake.

2) *Low Frequency Generator* If outputs greater than about 20 kw. at 100 volts are required, the frequency converter is used to excite a low frequency generator.

Such a machine was originally developed by Scherbius and bears his name. In appearance it is very similar to a d-c. generator. Fig. 9 is a photograph of a Scherbius generator.

The stator has some multiple of three semi-selient main poles that carry shunt fields. Interpoles are fitted between the main poles, and a compensating winding is wound on the faces of the main poles.

In order to keep down eddy current losses, the stator iron is laminated.

The armature carries a conventional lap wound d-c. winding, connected to a commutator. Its brushes are arranged in multiples of three and commutate the coils under the interpoles exactly as in a d-c. machine.

The machine differs from a d-c. machine in that the currents and fluxes are 3 phase and must be summed as vectors and not algebraically. This leads to some complication in the arrangement of the pole-face and compensating windings. Armature currents over any portion of the armature are compensated by currents from all 3 phases.

As the stator frame is laminated, it is not possible to adjust the interpole field strength by varying the interpole airgap. Coarse adjustment is achieved by adding or removing turns from the interpole windings. The interpole teeth laminations can be broken off to obtain finer adjustment.

A Scherbius generator has only about 70% of the output of a d-c. machine of similar frame size. The reasons for this are:

1) The iron circuit has to carry the peak values of flux, whereas the output is expressed in terms of the RMS value.

2) The currents are added vectorially and not algebraically.

At 3 or 4 cycles, the low frequency generator has been built to deliver up to 400 volts and to commutate 400 amps. satisfactorily. Such a machine is capable of handling a 1600 h.p., 4160 volt, 3 phase, 60 cycle motor with peaks of at least twice full load current. The practical output frequency of a Scherbius generator is about 10 cycles, because of commutation difficulties.

Conclusions

Commutator a-c. machines have been used quite extensively in Europe for many years for rolling mill, mine hoist, railway locomotive, and many other industrial drives. Low frequency equipment has already proved its worth in Canadian mines and new applications for it are continually arising. This paper has attempted to enumerate some of the characteristics and limitations of low frequency machinery and applications. The authors are confident that commutator a-c. machines can and will find increasing popularity in Canadian industry.

VOLUNTARY STANDARDS — VITAL TO PROGRESS

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Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June 1959.

The economic progress of Canada is dependent to a large degree upon the use of voluntary standards in industry. Two of the most important social-economic developments of the past century, interchangeability and mass production, were based on standardization. Measurable dollar savings and many broader benefits have arisen from the use of standards on an industry-wide or national basis. The savings and benefits are: fewer parts and finished goods inventory; more continuous employment by manufacturing for stock; longer, smoother production runs; and reduced training time of employees.

INDUSTRIAL standardization is a motivating force used by modern management to increase productivity. Productivity is the key to increased earnings and standard of living in an industrial economy. Productivity is achieved by simplification, which in turn is achieved by standardization of parts, finished goods and processes. Standardized products are lower in cost and selling price per unit, are easier to sell and easier for the purchasing agent to buy.

Voluntary standards are used internally by companies, by nations on an industry-wide basis and in the international field. A voluntary standard can be defined as a democratic organized solution to a recurring problem. Voluntary standards must be alive and subject to gradual change. They are non-mandatory and must not be detailed to the point where they hinder progress. Because it relegates solved problems to the field of routine, standardization frees creative facilities and human energies for the infinity of other industrial problems awaiting solution.

History

Standards have been with us since the stone age. Unfortunately they have have developed in a haphazard manner, unguided by those who are eventually affected by them. It is only during the past 85 years that organizations have been created to guide the formation of standards. It is worthwhile to briefly review the history of standards to bring into focus the importance of an organized standards movement. If we are to reap the benefits of new products and processes yet undiscovered management and its delegates need to increase their interest in and support of standards organizations in the national and international fields.

In ancient Egypt and Mesopotamia a brick maker made standard sun-dried bricks with the aid of a simple form. Until the form wore out the bricks produced had substantially the same dimensions. As time progressed other standards evolved. In 1101 A.D. Henry I of England proclaimed that the yard constituted the distance from his arm pit to the tip of his longest finger. This was an adequate standard at the time but is inadequate for to-day's precision requirements. Besides, none of us can remember the length of King Henry's arm! However, by common usage the yard has become a standard measure which is still used to-day, except that its length is now compared to the standard meter which is based on the length of green light produced by a neutron of mercury with an atomic weight of 198 when added to an atom of gold. 1,831,249.21 of these wave lengths equals a standard meter.

In the seventeenth century the idea of production of standard objects by the use of machinery and automatic processes hailed the beginning of the decline of the artisan. Little progress was made in this regard until the beginning of the nineteenth century when Eli Whitney, the inventor of the cotton gin and manufacturer of fire arms, applied the idea of interchangeable parts manufacture. With the aid of the U.S. Army and government officials, Whitney worked painstakingly for twenty years to smooth out the path for a new way of making guns. In 1824, the year of accomplishment, one hundred rifles were stripped and reassembled, proving that the parts were interchangeable. This was in effect the beginning of national standardization in modern industry. Probably the most significant development in the standards field took place in England in 1841 with the development of the screw thread standards. American screw thread standards had their beginning in 1864 and unfortunately differed basically from the screw thread standards in England, with subsequent disastrous results.

Standards Organizations

Standards organizations had their beginning on the international scene. In 1875 about twenty nations formed a General Postal Union, subsequently renamed the Universal Postal Union, and signed the International Postal Convention — the first general agreement standardizing and simplifying international postal rates. The same year the International Bureau of Weights and Measures was formed.

Prior to World War I the only national standards agency in existence was the British Standards Institution. World War I gave impetus to national standardization in all countries involved in that struggle and at the same time established the need for an international standards movement.

The oldest organization in the national standardization field in Canada is the Canadian Standards Association. Its formation was promoted in 1917 by the Engineering Institute of Canada and incorporated in 1919 by Letters patent under the Dominion Companies Act and named the "Canadian Engineering Standards Association". In 1944 the term "Engineering" was dropped. It is a non-profit, non-governmental organization which provides a national standardization body for Canada.

CSA has two subsidiary divisions, the CSA Testing Laboratories and the Canadian Welding Bureau. CSA works closely with other organizations which are interested in or devote all or part of their efforts to standardization. Some of the organizations in Canada interested in standards are:

- Canadian Electrical Manufacturers Association
- Canadian Electrical Association
- Canadian Government Specification Board
- Department of Trade and Commerce—Standards Division
- Department of Transport
- Associate Committee on National Building Code — National Research Council
- Electronic Industries Association
- Specification Writers of Canada Association.

CSA Standards and Codes of Practice are prepared by committees having diversified interest to ensure that the views of all interested parties are considered. It is significant to note that all standards issued by CSA are voluntary. They become mandatory only when adopted by an authority having jurisdiction such as a provincial government. For instance the Canadian Electrical Code which is strictly a safety code prepared by CSA is mandatory in the majority of provinces in Canada since it has been adopted by its governments. Regulations based on this code but with slight modifications are mandatory in the majority of the other provinces.

The International Picture

Standardization activity in the international field is still in its infancy despite ample evidence of its economic value. An immediate expansion is vital, and complacency and lack of foresight must be replaced by strong management support and awareness.

The penalties for lack of action in international standardization have been dramatically illustrated in the past. Chaos existed during World War II when ammunition used by the Americans could not be used in British and Canadian weapons and, naturally, vice versa. The position of the allies in North Africa was in peril at one stage because of the lack of screw thread standards. Damaged equipment lay idle and useless. An American Air Force mechanic characterized the situation when he exclaimed, "We can't borrow parts from the British. We can't even steal them. THEY DON'T FIT". Because of the difference between American and British threads it has been estimated that about 600 million dollars in the form of extra screws, nuts, bolts and spare parts were shipped abroad during World War II.

Lack of consideration of the importance of national and international standards resulted in an island of 25 cycle electric power in the industrial part of Ontario. At that time 25 cycle electric power had many benefits to heavy industry, which since have virtually disappeared. The conversion to 60 cycle was a costly changeover — approximately 375 million dollars.

Painful experiences like this undoubtedly contributed to recognition of the need for international standardization bodies such as those now in existence. Of notable importance are: International Organization for Standardization (ISO) of which the International Electro-Technical Commission (IEC) is a branch; the ABC organization which was formed by the United States, Britain and Canada primarily to standardize screw threads. By 1948, only a few years after its formation, the ABC team signed a Declaration of Accord which adopted a unified thread standard. This was a momentous step. These standards were published in the United States and Canada in 1949 and by the British Standards Institution in 1953. The ABC team has expanded its activities into other fields such as drawing practices and limits and fits. Considerable progress has been made in these two fields and in the near future common standards will materialize within the English speaking countries. Through the efforts of ISO these standards and many others eventually will become world wide standards.

The Canadian Standards Association is very active in ISO, IEC and ABC standardization bodies.

CEMA

A significant example of the benefits and economics obtained through national standardization are the standards which have evolved for electric motors and generators over the past fifty years. The guiding force behind these standards in Canada is the Canadian Electrical Manufacturers Association, commonly known as CEMA, of which the Motor and Generator Section is one of the largest groups. The standards which they publish are strictly voluntary standards.

CEMA was formed in 1944 when it was recognized that there was a need for an organization in Canada similar to the National Electrical Manufacturers Association (NEMA) in the United States. One of its prime functions is to guide the standardization of electrical products in Canada. Through CEMA assistance is given to CSA in formulating safety standards for electrical equipment and to other organizations in developing standard practices in the electrical field.

There are 31 product sections and divisions operating in CEMA and several standing committees. Its Codes and Standards Committee is the clearing house for all standards proposed by the various sections and divisions. This committee approves all standards before they are adopted and it approves recommendations for standards which are made to other organizations. All CEMA standards are submitted to CSA before they are published to ensure they do not conflict with existing CSA standards.

Standards for electric motors and generators were initiated about 1910, by AIEE in the United States. At that time no agreement existed among the various manufacturers as to what constituted a 5 h.p. motor or a 200 kw. generator. In competitive selling a salesman could claim that a 5 h.p. motor would carry twice the load. Purchasing agents had no way of knowing which manufacturers' motor was the best buy, short of carrying out complete tests. The standards developed in the initial stages were a system of ratings based on specified tests and accurate measurements of temperature at rated load. Permissible temperature rise was standardized for each type of insulation. These first standards were the result of industrial co-operation and many of the tests established at that time are still used to-day.

By 1926 the National Electrical Manufacturers Association was formed in the United States and took over the standardization of electric motors and generators. By the late '20s it developed a system of frame assignments for each horsepower and speed rating and standardized the critical dimensions for each frame. This was a great benefit to the industry as a whole. The user achieved interchangebility of all motors of the same rating in his plant allowing him to reduce the number of spares required and to purchase from several manufacturers. On the other hand the manufacturer benefited too. He no longer needed to supply motors which he considered non-standard to replace another manufacturer's make. Standardization encouraged him to stock completed motors since he was assured that all motor purchasers could use his product. Manufacturing in quantity for stock resulted in lower cost.

By eliminating the necessity of designing a motor for each order received, the design engineer redirected his energies to developing a full line of motors with the resulting reward of economies to his company and the user industry, as well as personal satisfaction to himself.

Some people may think that such a standardization program would retard advancement. Such is not the case since the only dimensions standardized were those which affect the mounting of the motor to equipment such as the shaft diameter, foot dimensions and shaft height. A great deal of scope was left for the ingenious design engineer to achieve the economies of the latest materials and processes developed. At the time this first standardization of frames was made, the ratings applied to each were the maximum achievable by the NEMA member companies.

Due to further advancement in materials and processes the industry was ready and preparing for a re-rating program when the second World War broke out. Naturally all energies turned to the war effort and the program was shelved. However in 1948 it was re-activated by NEMA and also by CEMA which was then in existence. All the latest advancements, ingenuity and experience were utilized in the new designs. This resulted in some frame sizes being dropped entirely, others were created, and the balance were up-rated considerably. The program resulted in considerable design and re-tooling expense to the CEMA member companies, but the economies and improved designs obtained justified the program.

Such a changeover program cannot be achieved without the utmost co-operation amongst the manufacturers and from the user industries. This co-operation was achieved and the transition made without chaos, in fact with only a few murmurs of dissent.

If there were no national standards for electric motors it is estimated that the selling price would be about four times greater than it is. This represents a saving to the Canadian economy of 100 million dollars per year. Add to this the savings realized by the thousands of other products and processes in Canada which are standardized on a national basis and you will appreciate the significance of the standards movement.

With the rapid advancement in insulation systems and materials and improvements in electrical sheet steel it may not be too many years before there is another re-rating program. When this takes place the temperature rise limit of the standard motor will probably also be increased provided the user industries will accept motors with higher operating temperatures.

There are some instances where CEMA has sought agreement with other industries with little success. For instance they have endeavoured to promote a standard oil burner motor in the industry but are continually receiving requests from oil burner manufacturers for special features peculiar to their own needs. Most close-coupled pump manufacturers have different motor shaft size requirements. The pump industry has not achieved agreement on a standard size. The electric utilities in Canada do not have a national standard for maximum and minimum voltage limits for each nominal voltage as do the electric utilities in the United States. The utilities in different parts of Canada maintain their voltage levels within their own chosen limits, some of which may be reasonable and others not. As a result electrical manufacturers often receive complaints that equipment supplied is not operating properly as a result of voltages which are too high or too low as compared to the nominal design voltage of the equipment supplied. As a result some users buy equipment having a special design voltage to meet the peculiar voltage conditions of their plant, at a price premium for the extra design and manufacturing expenses involved.

Eventually these differences will be resolved but in the meantime they are a problem to the user as well as the manufacturer. Manufacturing expenses go up and hence the selling price. Quality control suffers. Manufacturers cannot stock the user's requirements and hence deliveries are extended.

Conclusion

The standards movement, however, has shown marked progress during the past ten years. It must continue to progress and broaden its scope if we are to take full advantage of the benefits of automation and new products and processes. No longer must a statement made by a leading industrialist in the late 1930's be permitted to find application. He declared, "Where proper standardization has been delayed beyond the time when it should have been done, the very turmoil and chaos of the resulting situation almost automatically impelled conflicting interests to seek a common meeting ground. Further, from the welter of confused experience there is much material that can be salvaged in the making of a standard".

Today, strong measures must be exerted because of a common recognition of advantages to be gained — not because of a welter of confused and costly experiences. To quote Robert E. Gay of the U.S. Department of Defense, "Automation is in a transitional phase as is our entire system of production. In the early course of this phase, new processes, new products, and whole new industries are springing up, pushing back our horizons into new worlds. There is an opportunity here to do what we have never done before: To standardize in advance of need, to use standards in accordance to their proper, creative, pre-planning functions, instead of as correctives of serious trouble".

Future economic progress in this country will depend upon Canadian industries' ability, on a voluntary basis, to modify existing standards to take advantage of new products and processes; to create standards for existing products where benefit to the economy will be realized and to create standards for new products as they are developed. The program of achievement rests on the shoulders of industry management. The producer and user industries must work together in teams to achieve the common goal — progress.

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DISCUSSION

of Technical Papers and Other Articles

ECONOMICS OF BY-PRODUCT POWER GENERATION

W. M. Newby, M.E.I.C.
Consulting Engineer,
Niagara Falls, Ont.

W. P. London, M.E.I.C.
Chief Engineer, Thermal Division,
H. G. Acres and Company Limited, Niagara Falls, Ont.
The Engineering Journal, December, 1959, p. 63.

Authors' Reply

The authors agree with Mr. Dye that the possibility of providing steam and power for industry from a plant owned and operated by a utility presents interesting possibilities.

In working out the most economical design of such a plant there are, as he points out, a number of problems which were not touched upon in the paper. We would certainly agree that the proportioning of the exhaust end of the turbine and condenser so as to give optimum economy is one of the more important. As to the use of a steam air heater to improve cycle efficiency, this arrangement can be and is used, not only in by-product power installations, but in conventional generating stations as well. For one installation with which the authors are familiar where a cold end temperature of 250° F is necessary, it has been found economical to heat the combustion air to 150° F and the overall reduction in plant heat rate amounts to 9.0 B.t.u. per kilowatthour. In a by-product power plant, due to the higher ratio of steam production to energy output, the saving expressed in the same terms would, of course, be somewhat greater.

THE FIRST CYCLONE FIRED BOILERS IN CANADA

E. K. Akin, M.E.I.C.
Senior Mechanical Engineer,
Nova Scotia Light and Power Company Limited, Halifax, N.S.
The Engineering Journal, October, 1959, p. 85

Authors' Reply

Mr. Hymmen in his discussion has asked a number of questions, some of which must be answered in a general way since our records in some cases are not extensive enough to give a definite answer.

With regard to the questions:

(1) What capital expenditure is justified for a unit of this size *due to fuel saving alone,* for each 1% gain in efficiency at the prevailing capacity factor and fuel cost?

Evaluating this on the basis of 60% capacity factor and our present high cost of coal an additional expenditure of about $110,000.00 would be justified for each 1% gain in efficiency.

(2) Are predicted results being achieved with respect to:

(a) low excess air—Yes, we are able to follow closely;
(b) Low exit gas temp.—Yes, with air heater and boiler surfaces kept clean;
(c) Low carbon loss—carbon loss is very low on any checks made, less than ¼ of 1% in slag.

(3) What maintenance problems and expenses are being experienced?

Not able to give definite figures but maintenance has been reasonable. Original wear blocks still in primary burner scroll of No. 6 unit. Surfaces built up by welding on several occasions.

One slag spout cooling coil burnt out. Both oxygen probes replaced, also a number of spray tips. An accounting system is being set up to keep better records.

(4) Has the pressurized method of firing caused abnormal difficulty or expense in operation?

No particular difficulty with pressure firing. A few casing leaks developed in the early stages.

The air requirements for the aspirated observation doors have added to the expense as additional compressor plant was required.

(5) Has the low exit gas temperature caused any fouling or corrosion in the expendable cold end section of the air preheater?

I am happy to say that to date there has not been any corrosion or sulphur deposits in the air heaters. There has been some tube plugging with loose and dry fly ash, possibly due to light load operation and low velocity.

(6) Additional information and test data has been requested when using the high level burners for boosting steam temperature for two shift operation.

The high level burners have been found very effective for boosting steam temperature. However, our experience in their use has been rather limited, as we have had very little 2-shift operation. One of the difficulties has been measuring the gas temperature entering the superheater tube bank, i.e. to get a representative temperature or to locate the highest temperature zone. Further studies will be carried out when the plant is called on for 2-shift operation.

Mr. Broad asked what percentage of total power is required to drive the forced draft blowers.

I am not able to give the percentage figure but the overall figure for station service including all auxiliary power is 6.5 to 7.5%, or about the same range as our pulverized fuel fired boilers using the same class of fuel.

Mr. Broad stated that in Cyclone Firing, since all of the air must be raised to a static pressure of 30 in. or more, the power required to sup-

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AUTOMATION AND CONTROL ENGINEERING IN CANADA

Introduction

THROUGHOUT 1959, *The Engineering Journal* featured a series of articles on "Instrumentation in Industry". These articles were based on the replies to a questionnaire which was distributed widely to users of instruments in a number of industrial classifications. The material received was tabulated to give background reference figures, and the various remarks advanced by respondents were incorporated into a short text. It is hoped that, by confining the questionnaire to persons interested only in the use of instruments, a general picture of instrument usage in the industrial classifications chosen would emerge.

There is evidence that this objective was partly met in the 1959 program, but it is also evident that there were serious deficiencies in the method chosen. The title "Instrumentation in Industry" was so broad that it proved impossible to cover it adequately in a simple questionnaire. As a result, many of the questions were interpretive, and the pattern which emerged was far from satisfactory from the technical point of view.

Editorial investigation into the matter by the editorial staff and the various committees of the Institute resulted in the recommendation that a new approach be investigated for 1960, and the series which will follow in the next eleven months is the result. We hope that it will prove to be a significant contribution to this field of engineering activity, which is rapidly assuming vital importance in Canada's industrial future. We already have in this country some of the most advanced automated industrial plants in the western world, and experience gained in them will help to shape usage in other countries. Our economy, with the high labour costs inherent in our advanced standard of living, demand that we utilize the most advanced concepts of modern technology if we are to retain a satisfactory position in world markets. In no direction is there greater promise than in the wise and ingenious use of automation and control engineering techniques.

There have been many vital and interesting developments in this field during the past few years, and not all of them passed the final tests of wide acceptance in industry. Static switching has not yet fulfilled its early promise but it has been gaining important support in the United States as a technique for controlling complex processes in the steel industry and in warehousing. The main drawback seems to lie in the complex circuitry of static switching systems, which points to a new requirement for better testing and fault locating devices, and more convenient "packaged" replacement units. Machine tool controls, which were originally regarded as the natural outlet for static switching, have been recovering from the depressed activity experienced during 1958 and early 1959, and a great deal of attention is being given to the production of cheaper controls tailored for the small and medium-sized machine shop. A number of people engaged in this field inform us that their objective is to market machine controls which small shops cannot afford to do without, and they are making considerable progress towards this goal.

A great deal of interest is being shown these days in the extension of the power handling capacity of control equipment. Extensive investigation is being made which shows promise of extending the range of d.c. Servos and servomotors up to 1½ or 2 horsepower.

In the fields of closed-loop control, there is still a considerable amount of controversy over the relative merits of electronic systems versus hydraulic or pneumatic systems, or combinations of the two. It depends to some extent upon the control problem at hand, and there is understandable reluctance in some quarters to invest heavily in electronic systems when the cost is usually quite high, the maintenance problems considerable, and the advance in technology so rapidly changing. The development of transistors compatible with control requirements make some of the older amplifiers and circuit elements appear less attractive, and general advances in solid state techniques have been so startling that the control engineer contemplating new installations is confronted with a very complex problem. On the other hand, hydraulic and pneumatic systems have been improving steadily, some of it due to the need for better systems for high performance aircraft and missiles. Military research has conquered many problems which promise to extend the line of usage for industrial equipment using hydraulic or pneumatic techniques.

These are but a few of the items which will be discussed from the users point of view in the coming months. Through the cooperation of local branches of the Instrument Society of America, we have invited a number of outstanding Industrial Control Engineers to contribute one or more articles on the state of automation and control in their industry. We have given them a free hand in the presentation of their subject, but we hope to obtain a series of "inside" articles which will explore the viewpoints of a number of persons whose speciality lies in the application of better control methods to process and manufacturing industries. We hope that they will describe what they have done, will outline some of the philosophy which has guided their choices, and will give us some idea of what we should expect in their industry during the next few years.

Canadian Developments

Metropolitan area, exurbia, suburbia—perhaps these are all terms which need never have come into being. Two possibilities come to mind. The first is that the city might have remained in concept what it was some 700 years ago. At that time tradesmen referred to the "liberty" of the city which allowed them to market their skills and wares more swiftly and simply than the country ever had. One asks then, why didn't the city grow up as a dynamic but self-contained market-place and leave the country for living?

Again, an alternative to our sprawling cities might have been metropolises built for living as well as working. William Zeckendorf, noted planner of central development, has spoken of cities rotting at the core. Others have assailed the method so far used to stop the rot—that is, the move to build great apartment blocks in the very centre of the city. The truly residential city would have to be made up of apartment houses conceived as dwellings, not as adjuncts to commercial buildings, with exteriors like banks and interiors like executive suites.

But we have a distinct, essentially non-residential metropolitan area. We have ever-extending suburbia. And the latest development is a new limbo beyond the circumference of suburbia — the self-sufficient unit known as exurbia. Engineers, in town planning and building, are as responsible as the architects and the sociologists. They have helped to make what we have now and will have a hand in deciding how it is to be transformed for the future.

The engineer enters the picture only in so far as he builds these structures and in so doing puts the final stamp on any construction project. As a mechanical engineer he is likely, if informed of the aesthetic considerations, to be able to abet the architect's knowledge of what in design is practicable. However, to some this divergence from specialization may seem pure folly. For them municipal planning still holds one consideration and perhaps it is the most important of all — the integration of many and various plans for a single city.

Municipal Planning

Integration of Montreal Planning

David Owen, vice-president of Webb & Knapp (Canada) Ltd. who are building the Place Ville Marie Development at the corner of Dorchester and University Streets in downtown Montreal, has outlined an integration program which he considers essential to Montreal's future vitality. The steps are: to determine an adequate means of public transportation to accommodate a growing public; to discover a means for bringing the increased volume of passenger cars into the city and getting them parked; to plan for a route to carry vehicles going from West to East (or vice versa) but not stopping in the downtown area; and to modernize the waterfront so that it can serve the city economically.

Place Ville Marie had its beginnings over 30 years ago, when the management of the CNR began to look for ways to rebuild "the Dorchester Street hole" and unite it with the surrounding area. The 313,000 sq. ft. tract circumscribed by Dorchester on the South, Mansfield on the West, Cathcart on the North, and University Street on the East, went under development in late 1958. The

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The new mining town of Gagnon 150 miles northwest of Sept Iles, Quebec, is composed of a group of multiple dwellings (left); bungalows and facilities for unmarried personnel including five dormitories, recreation hall and dining hall (center); and shops and temporary barracks for the 700 men working on the construction program. The entire project calls for an investment of approximately $200,000,000 and should be completed in the Fall of 1960.


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• CANADIAN DEVELOPMENTS

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main building is to be the 42-storey cruciform office building. Six acres of plate glass and an equal amount of anodized aluminum will go into the construction of its exterior walls.

Excavation began in September for another skyscraper on the Dorchester Street-University Street site. The 31-storey C-I-L House will house 5,000 office workers and provide an additional rentable area of 600,000 sq. ft. Canadian Industries Limited will occupy 12 to 14 floors of the new building. Among outstanding architectural features will be a 41 ft. base which will eliminate most of the interior structural columns and provide underground parking facilities for 400 cars.

Also under construction at this site, and due to be completed in May, 1961, is the Canadian National Railway's 17-storey headquarters office and garage building on Lagauchetiere and Mansfield Streets. This is the fourth building in a long-range Canadian National program which includes Central Station, the International Aviation Building and the Queen Elizabeth Hotel.

One of Montreal's more stagnated areas, just four blocks east of the city's central shopping district, is to be transformed by a new building for the performing arts, the Sir Georges-Etienne Cartier Centre, more commonly known as Place Des Arts. One proposal made by the municipal planners has been to make the property a block south of the prospective Place Des Arts site available to the Canadian Broadcasting Corporation for construction of a new centre for its activities. If the CBC were to accept the idea, planners contemplate the possibility of a midtown park area and mall to connect the two properties.

The subway system which Montrealers have talked of for several decades is still far from realization according to the present signs. Although a private organization, La Societe d'Expansion Metropolitaine, proposed a $163,000,000 subway project to the city administration in early November, little headway has been made toward its acceptance. At present neither the City of Montreal, the Montreal Transportation Commission, nor the Montreal Metropolitan Corporation has the power to build or participate in the construction of a subway. However, both the city and the Metropolitan Corporation are seeking appropriate legislative authority.

Survey of Drumheller, Alberta

The City of Drumheller, Alberta is to be the subject of a survey by an independent firm of business consultants and engineers to determine the industrial and economic potential of the municipality and district. Under the auspices of the Industrial Development Branch of the Department of Industry of Alberta, the private firm will establish the physical area of influence of the city to allow a close evaluation of marketing and other potentials. The assets and liabilities of the community will be clearly set out to permit an impartial consideration by potential new industries.

Residential Planning

Enquiry Into Canadian Residential Design

The Royal Architectural Institute of Canada, with $30,000 support from the federal government, has launched a full-scale enquiry into the design of residential areas in Canada. Four prominent Canadian architects, Peter Dobush, of Montreal, John C. Parkin, of Toronto, C. E. Pratt, of Vancouver, and Robert Cripps, of Toronto, will complete their 17-week tour of Canada in January, having travelled 9,000 miles and visited 15 major centres from Victoria to St. Johns.

As well as making this visual survey of the nation's residential areas, the committee has invited a wide variety of opinions and advice in the form of briefs and submissions from the house-building industry, lending institutions, transportation consultants and consumer groups.

While visiting Montreal on November 10, the committee heard a brief describing the kind of apartment buildings being built in the area of Guy, Atwater, Sherbrooke and St. Catherine Streets as "haphazardly constructed and located in such a way as to destroy each other's amenities." A plan was proposed as a possible solution to the downtown residential problem which included: provision for sunlight and fresh air, adequate recreation space, proper parking facilities and reduction of the effects of traffic on the inhabitants. The basic plan called for the residential block to be built one level above the street so that normal traffic and parking facilities could be maintained while the apartment units would be above traffic noise. They would be spaced to provide maximum air between units.

The C-I-L House will rear its head high at the corner of Dorchester and University Streets, Montreal, by mid-1962. The downtown section of Dorchester Street is undergoing extensive redevelopment and the thoroughfare itself is to be widened and somewhat rerouted west of Guy Street.

Communications

Toronto's Solution to Traffic Problem

Metropolitan Toronto Traffic Director, Sam Cass, reports that the city's traffic has reached the chaotic stage. While auto registration continues to increase at a rate of 5% a year, the roads system increases at a meagre 1%. In the last three years the volume of traffic pouring into Toronto from other points in the province has doubled. A Metro technical committee has been established to consider three possible solutions: an additional five or six new roadways from the suburbs into the city; conversion of many roads in the 260-mile Metro road system into one-way routes, allowance for exclusive TTC bus lanes and widening of roads; or special subsidization of railway lines and TTC bus lines to draw motorists off the roadways in rush hours.

A network of six expressways is provided for, and two are already under construction, as part of a 10-year program, but they will be only beginning in the relief of extensive traffic congestion.

Ottawa Initiates Interconnected Traffic Signals

Traffic signals at fifty intersections in Ottawa's central business district were recently interconnected to form a single traffic control system. The master-controller in Ottawa's city hall automatically selects the signal timing best suited to prevailing traffic conditions. Intensive studies of traffic flow conditions will permit the city's traffic engineering department to establish a timing program which can be followed each day throughout the year. The program can be changed 60 times during one day. The system also permits central control of other illuminated signals such as "no left turn" signs, directional arrows and pedestrian signals. Provision has been made to establish emergency routes for the fire department and evacuation routes for civil defence.

Many cities have had small interconnected systems for some time, but the coordination of 50 intersections gives such a plan much greater scope. The cost of installing the cable to make such an interconnection has long been prohibitive, but the Ottawa network utilizes telephone lines for transmission of messages.

Vancouver Proposes More Freeways

Vancouver's answer to increasingly large traffic problems is to build more freeways. The traffic planners predict that over the next 17 years their construction will take $374,000,000. Many commuters have been opposed to the $23,000,000 expenditure on the nearly completed Second Narrows Bridge because it leads to a part of town which they do not need to go to. They have also opposed the suggestion that they revert to public transportation. The planning experts propose a system of freeways which would bring an area of 200 sq. mi. within 30 minutes' travelling distance of the downtown area.

The Finance of Planning

Hamilton Publishes Five-Year Report

A report and analysis of Hamilton's five-year capital budget prepared by

• CANADIAN DEVELOPMENTS

Dr. C. C. Potter of McMaster University has recently been made public. Financed by the city's chamber of commerce, the report shows how one major city is handling the problem of financing and planning its capital expansion projects.

Toronto's 1960 Budget

Metro Toronto's Roads Committee has recently approved a 1960 budget of $25,010,000, an increase of $6,540,000 over 1959. It includes: $9,000,000 for the Gardiner Expressway, $5,000,000 for the Don Valley Parkway, and $300,000 for preliminary engineering on the proposed Spadina Expressway.

Municipalities Ask For Federal Aid

The Canadian Federation of Mayors and Municipalities has been urging the federal government to implement policies which would enable them to carry out more heavy construction projects. In a brief submitted to the federal government they stated: "Unless there is a marked change from the present situation and outlook there could develop a serious setback to the progressive effort which municipal governments have been making in an endeavour to keep pace with their urban growth requirements." The federation asked that a national municipal loan fund also be established.

Planned Communities

Summer Cottage Developments

Saskatchewan residents are being urged to build their summer cottages in a planned resort. Mr. Z. Bakun, director of the Community Planning Branch of the Department of Municipal Affairs, points out that summer cottage developments are urban in nature and therefore require controls of an urban community. He believes that it is in the builders' interest that cottages should be constructed in properly planned subdivisions, developed in suitable areas and served with proper facilities.

Newfoundland Establishes New Towns

The Newfoundland government has instituted a program to establish centralized communities complete with churches, schools and hospitals as well as housing to replace the scattered and isolated settlements characteristic of the province. Numerous sites have been opened for development in the St. John's area as a start.

Current Events

Seaway Season Closes

The Rockcliffe Hall, a 252 ft. Canadian canaller, was the last ship to go through the St. Lawrence Seaway this year. With its passage on December 4 the first full season of operation of the locks and channels between Lake Ontario and Montreal came to a close.

Preliminary traffic statistics issued by the Canadian and United States seaway authorities show that 17,400,000 tons of cargo were carried through the St. Lawrence Seaway (Montreal-Lake Ontario) in the current navigation season to the end of October. This figure is 7,300,000 tons, or 72%, in excess of the quantity of cargo carried by the old St. Lawrence canals in the corresponding period of 1958. The upbound movement increased by 5,500,000 tons (128%) and the downbound by 1,800,000 tons (31%).

INTERNATIONAL NEWS

A town where pedestrians never meet traffic, where cars are allowed only on roof tops and people travel from one area to another by water bus has been envisaged by a group of London architects. Requisite to the building of their city, however, is a network of flat, 50-ft-high roofs, and this removes the plan from the realm of immediate feasibility. "Motopia" might be a prototype for the cities of the 1980's, but we are at present faced with quite a different picture. In most of our cities the system of roads needs untangling and many of the buildings themselves must be redesigned or replaced.

Since the end of the war France has built 1,620,000 housing units of which only 300,000 have been reconstructions. Her average rate of population increase (300,000 per year) has been the greatest of any country in Western Europe, and she has had to try and meet the demand. The capital for this development has had to come largely from the government. With this financial support, the French construction industry has taken long strides to cut down the need for large labour forces and to increase the on-the-site productivity rate. Prefabrication and assembly-line construction have been her methods.

France has made notable progress in developing building systems using steel, aluminum, clay blocks, and precast concrete. Two such systems are the Fillod System of steel sheeting for outer walls and the Phenix System, a combination of light steel and framework and concrete block filler.

The Paris headquarters of the Federation Nationale du Batiment is an admirable example of France's recent work in aluminum. The internal and external walls were constructed separately and connected by small insulated straps to prevent any transmission of heat through the metal. Between the walls is a soft 20 mm thick "Isorel" sheet and on either side of that a creased 4/100 mm thick aluminum coated paper. The wall reflects both internal and external radiations and assures thorough interior ventilation.

London Continues to Expand

A British government research officer fears that before long London may become a solid urban concentration at least 100 miles across. According to him, "The geographic and economic attractions of the metropolis are too strong to be controlled by planners." He cites the fact that over the last seven years 40% of the national increase in employment has taken place in the London region. In the nine square miles of Central London 200,000 new jobs are being created yearly. The population of the area at a radius of 12 miles from the city's centre has increased some 660,000 since 1951.

Two situations emerge. Towns near London, like Brighton, Luton, Reading and Southend, risk being swallowed up. At the same time more people are building well out of London and buying cars to bring them to their London jobs. The country is taking on a suburban air as new "dormitory" towns grow up by the sea.

In London, as in all the big cities, concentration and centralization are the motifs in commercial building. The British Broadcasting Corporation is building a new television centre at Shepherds Bush Green next to the White City Stadium, at one of the city's worse congestion points. The building presumably replaces countless theatres scattered around the city by one consolidated unit. The traffic problem is all too apparent.

"Motopia" is the name given to a revolutionary town designed by London's Glass Age Development Committee to house 30,000 people. In the foreground is a road linking the ground-level network with the rooftop road system. The low building under the overpass is a station with its own roof parking area. Above the shopping area looms a 20-storey block of administration offices for 3,000 workers. The roof level is a uniform 50 ft. high and traffic on it is made invisible by hedges, inaudible by special ceiling insulation.

Sweden Excels in Self-service Stores

Recent figures show that Sweden leads Western Europe in the field of self-service stores. Her one self-service store for every 1,800 inhabitants can be compared with Switzerland's one to every 3,400 people and West Germany's one to every 5,900. In Sweden the proportion of food turnover handled by self-service stores is estimated at over 20%.

The Swedish Institute of Economic Research has calculated that 69,000 housing units were built in Sweden in 1959. In 1957 and 1958 alike about 60,000 houses were constructed, an increase of 10,000 over preceding years.

Germans Convert Munitions Factories

Not long ago the West German community of Espelkamp-Mittwald was granted the status of a town by the

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North Rhine-Westphalian government. Just twelve years before, in 1947, it had been nothing but a collection of old ammunition factories and explosives depots about to be demolished. A Swedish visitor, the Reverend Birger Forell, in Germany after the war to discover ways of housing prisoners-of-war and refugees, had the idea of converting the ruins of Espelkamp into a residential community. Today more than 2,000 living quarters have been constructed there and 5,000 people earn a living in the community.

Danish Apartments Erected in Germany

Danish builders have put up 116 pre-assembled apartment units in Hamburg, Germany during the last quarter of 1959. A growing housing shortage and a lack of skilled construction workers led the city authorities to survey the European scene for a quick remedy. A Copenhagen firm was contracted to produce all the apartment components in their home plant and ship them to the site ready for quick erection. Floor and ceiling slabs, complete with all necessary horizontal utility lines, door frames, doors, and hardware were prepared in Copenhagen. Windows arrived with glass in them. Bathroom units were equipped with plumbing fixtures ready to be hooked up. Two apartments a day were completely assembled ready for heating, and the whole job was overseen by three skilled workers — the crane operator and two supervisors from the Copenhagen plant.

Pittsburgh Sets Planning Precedent

The Allegheny Conference on Community Development went to work to rejuvenate Pittsburgh in 1947. In the twelve-year period, working through citizens' committees, they have succeeded in ridding the city of its smoke problem; constructing flood protection; clearing traffic congestion through a system of freeways; and building up a complex of modern office buildings and parks. Corporations, foundations and individuals have supplied the funds for Pittsburgh's momentous redevelopment.

One of the many new buildings reaching completion in downtown Pittsburgh is the $20,000,000 public auditorium. It is part of a cultural centre which is to occupy the city's Lower Hill area. An open-air amphitheatre and sports arena, a convention hall and an exhibition centre will be housed in the new circular structure under a retractable steel dome. Its seating capacity will be close to 14,000, including one section of 2,100 permanent seats covering the stage. These can be tilted out of the way hydraulically when the 119 x 64 ft. stage is needed.

The dome, composed of six movable sections and two fixed, rolls along rails anchored to a 20 ft. wide concrete ring girder which encircles the auditorium. It takes only a push-button to put it in motion.

Soviet Envisages Dam Across Bering Strait

Melting the ice sheet of the Arctic Ocean is the task Soviet Engineer and Stalin Prize Winner Pyotr Borisov has set for himself. According to Borisov, if the Gulf Stream's warm currents were allowed to flow into the Arctic Ocean from the Atlantic the ice would thaw in no time. At present the Labrador and East Greenland currents render the Gulf Stream cold and impotent. Together they run under the ice sheet without affecting it.

If a dam with pumps were built across the Bering Strait, he maintains, the water from the Arctic Ocean could be directed into the Pacific, leaving the Gulf Stream to flow warm under the ice sheet. Once the ice was melted, up to 90% of the sun's warmth now reflected into space would be retrieved. Immense areas of tundraland in the U.S.S.R., Alaska, and Canada would thus be made habitable, says Borisov.

Reconstruction in Peiping

The population of the capital city of Communist China has doubled during the last five years and the increase has resulted in a drastic housing shortage. Occupancy standards have been set at 10 sq. ft. minimum floor space per person to meet the problem of housing 5.5 million people. As a point of comparison: the Philadelphia Housing Code requires 150 sq. ft. for the first occupant, 100 for the second, and 75 for each ensuing.

The government has been granting loans to repair some 40,000 rooms in Peiping and to build 46 million sq. ft. of new housing space. Twenty-eight new industrial plants have sprung up in the southeast area of the city. Perhaps the most dramatic step has been the demolition of the old city walls to allow the East and West Chagnon Boulevards, modern eight-lane thoroughfares, to meet.

Electrification of Southern India

The following is a summary of a talk given by Messrs. P. S. Subramanian and A. Subramanian of the Madras State Electricity Board at the October 20 meeting of the Saguenay branch of E.I.C.

J. R. Easton, Correspondent

Electrical power first became available in 1909 and then only to the few wealthy people in Madras City. Expansion was slow until 1925 when the first big hydroelectric development took place — big for that period and part of the world. In 1947 the Madras State Electricity System was nationalized and since then has expanded at a tremendous rate. Since 1950 its installed generating capacity has increased by 400% to 600 megawatts.

The expansion of the Madras State Electricity Board has been organized into 5-year plans. The second such plan is drawing to a close now. In each of the first two, installed generating capacity has doubled and during the third plan it is to almost double once again.

Hydroelectric installations are accounting for roughly three-quarters of the expansion. However, at the end of the third 5-year plan all available potential hydro sites will have been exploited. The Board is now looking elsewhere for more sources of power.

States to the west and northwest of Madras have large potential sources of hydroelectric power — more than they need for their own development. Madras is negotiating for the development of particular sites within these states and the diversion of water eastward into Madras State.

The Central Government of India is developing large lignite coal fields in the State of Madras, creating several new chemical industries and work for many people. It is also building a large thermal electric power station. The Central Government is also considering the construction of two atomic power stations — one in the north and one in the south, the latter in the City of Madras.

So much recent and proposed electrical development and expansion in Southern India has led to a council being formed. It will organize the interconnection of the power systems that exist in the several states concerned. This will benefit those states which are very heavily populated and are short of power.

The major portion of the power consumed is used in the pumping of water for irrigation to increase the production of food. All other uses are secondary to this. Approximately 70,000 pumping units exist today and this is expected to reach 100,000 within a few years. This power demand is greatest during the dry season months of April, May and June as rice-growing requires a constant 8-9 inches of stagnant water on the fields during this interval.

Because of the shortage of power at normal peak load times, work within industries is scheduled carefully. The Board has over 11,300 miles of high voltage transmission line and 15,000 miles of low voltage transmission line. Electricity is supplied to power consumers at 400 volts and to domestic at 200 volts. If a customer has an electrical load of 75 kilowatts or higher, the customer is supplied power at high voltage and must instal his own transformers and switch gear.

(Continued on page 86)

• DISCUSSION

(Continued from page 72)

ply the air at this high pressure offset any saving made by not having to pulverize the coal.

Data gathered from various boiler installations indicates that the auxiliary power requirements for a cyclone fired unit and a pulverized fuel fired boiler are approximately the same when burning coal having a grindability of about 55. The compressor effect of the blowers operating at high static pressure adds 20° to 30° to the air temperature. This gain in temperature is recovered and represents an increase in efficiency of about ½ of 1%.

Mr. Broad's comments regarding the suitability of various coals for cyclone firing certainly raise an important consideration. Generally speaking most coals having an ash softening temperature of 2400° F or less are suitable for cyclone firing. However, samples must be analyzed to determine the suitability of any particular coal. The greater percentage of the coals mined in Canada and the United States fall within the requirements for cyclone firing.

LITTORAL DRIFT IN LAKE ONTARIO HARBOURS

A. Brebner, A.M.I.C.E. and
R. J. Kennedy, M.E.I.C.
Queen's University, Kingston, Ont.

The Engineering Journal,
1959, September, p. 85
(Further discussion)

Dr. Brebner's reply to points raised by Mr. E. S. Bell.

1) Fig. 12 Caption should read "typical off-shore Breakwaters"

2) On Figs. 2 and 6 the ordinate should read "Percentage Retained On" not "Percentage Finer Than"

3) With regard to part 2) in the reader's criticism — which may be in the discussion?—my answer would be:

Fig. 2 definitely indicates a well graded sand from a soils point of view whereas Fig. 6 indicates a uniform but poor grading from a soils viewpoint. The "excellent" in the text was meant to refer to Fig. 2 but the authors realize the ambiguity of this statement.

Month to Month

McGill's McConnell Engineering Building Opened by Governor-General

The official opening of McGill University's McConnell Engineering Building on November 30 by the Queen's representative is a fitting tribute to the growth of engineering education in Canada begun at that university one hundred and four years ago. At 12:15 p.m. the Governor General, His Excellency Georges P. Vanier turned a ceremonial key, thus unveiling a commemorative plaque in the main lobby and an array of decorative flags. The General Secretary of the Institute, Garnet T. Page, and Dean Henri Gaudefroy of Ecole Polytechnique attended the ceremony, Dean Gaudefroy representing President J. J. Hanna who was unable to be there.

The central spine of the new building, rising eight storeys, houses the highly specialized research facilities of the Electrical Engineering Department as well as staff offices and a conference room. The rest of the building, two five-storey wings, is for general use and includes two large auditoria, thirteen classrooms and eight drafting rooms. Of particular interest is the Computer Centre on the fourth floor which houses an IBM 160 digital computer. The Anechoic Room in the basement of the building, one of very few such chambers in Canada, provides an opportunity for acoustical research.

Fiftieth Anniversary of South African Institute

The Golden Jubilee of the South African Institute of Electrical Engineers, held in Johannesburg from September 5 to 9, comprised a full-day trip to the Premier Diamond Mine in the Transvaal, another to the West Driefontein Gold Mines near Carletonnville in the Western Rand, the Bernard Price Memorial Lecture, "Fission and Fusion" by Dr. T. E. Allibone, director of the research laboratory of Associated Electrical Industries Ltd. (England), and a finale banquet at which Sir John Maud, United Kingdom High Commissioner, spoke to the gathering of more than 500 members, delegates and special guests. F. H. Chapman, M.E.I.C., represented the Institute at the fiftieth anniversary festivities.

First Pan American Congress

Dr. Luis Migone, founder of the Pan American Federation of Engineering Societies (UPADI) and president of the Argentine Union of Engineering Associations and the South American Union of Engineers, was the guest of the Institute at a special luncheon held at the University Club in Montreal on November 3. Dr. Migone has been delegated by the Argentine government as its envoy extraordinary to establish contacts with "the highest authorities of the government, the universities and the professional groups of America in order to invite them to send not only representative delegations but also studies related to the agenda of the First Pan American Congress of the Teaching of Engineering, which is to be held in Buenos Aires in September 1960."

Toronto Quality Control Society

The Toronto Quality Control Society has scheduled two meetings this month, a panel on tool engineering, January 6, and a discussion of tolerancing led by Stan Prout of Canadian Controllers Ltd., January 19. This second meeting will be held in the Canadian General Electric Auditorium, 214 King Street West, Toronto, and will begin at 8 p.m.

Queen's Graduate Program in Nuclear Engineering

Queen's University is offering a one-year graduate program in nuclear engineering "to familiarize engineers with the basic concepts of nuclear energy and with the special problems that arise in the design of nuclear reactors and in the industrial applications of nuclear radiations." The course is restricted to graduates in engineering and engineering physics. Applications must be filed before April 1, addressed to The Dean, Faculty of Applied Science, Queen's University, Kingston, Ont.

Industrial Lubrication Course

The next course in Industrial Lubrication sponsored by the Toronto Section of the American Society of Lubrication Engineers is being offered through the extension department at Ryerson Institute of Technology, Toronto. Six lectures of two hours each will be given on consecutive Wednesday evenings starting January 27. The sessions, conducted by prominent members of industry and the teaching profession, will stress the basic principles and practical knowledge of lubricants and lubrication. Requests for further information regarding the sessions should be sent to Mr. K. J. Dean, Shell Oil Company of Canada Ltd. or Mr. H. S. Ostrander, Sun Oil Company Ltd., both of Toronto.

Traffic Engineering Course at Toronto

The University of Toronto's University Extension Section has recently announced an introductory course in traffic engineering to be conducted during the winter term, 1960. Beginning on January 21 and continuing to March 24, the lectures will be given each Thursday evening at 7:30 p.m. in room 128 of the Mining Building at the university. The course will attempt to give a basic introduction into the problems of traffic movement, control and planning. Registration may be made through the director, University Extension, 65 St. George Street, Toronto 5.

Middle East Technical University

In March, 1960, the charter of the Middle East Technical University at Ankara will come into final and effective operation and the university will cease to be under the aegis of the civil service administration. The university now has 500 students, and architecture, engineering and physical and administrative sciences are its specialties. The charter underlines that it is important for all concerned with the university to keep in mind the long range program which envisages, after 10 to 20 years, a university of 20,000 students with numerous research facilities. The Middle East Technical University is financed in large part by the Turkish government and by organizations such as the United Nations' Special Fund Committee.

Rewording of Certificates of Approval

The Inter-Service Equivalents Board, as a result of apparent misunderstanding concerning the Certificates of Approval issued by that body, has amended them with the following: "This Certificate is valid only for the project shown, and for the specific use indicated by the specification reference. Unauthorized use of this certificate for advertising or promotional purposes is not permitted."

New Australian Trade Commissioner

The Australian government has recently established the post of Senior Trade Commissioner in Canada and named W. Rupert Hudspeth to fill it. Mr. Hudspeth has had extensive chemical and engineering experience in Australian industry and was leader of an Australian Government Trade Mission to South-East Asia in 1955.

1960 Nuclear Congress

A partial program of sessions planned for the 1960 Nuclear Congress to be held in the New York Coliseum April 4 to 7 has been announced by Dr. Clarke Williams, chairman of the Nuclear Engineering Department of Brookhaven National Laboratory, Upton, New York, and chairman of the Congress. It includes: Problems of Fuel Technology; Development of Nuclear Standards; Industrial Applications of Isotopes; Nuclear Propelled Aircraft and Space Vehicles; Research Reactors and Radiation Facilities; Progress in Reactor Instrumentation; and Advanced Reactors and Fuel Cycles. The Congress is sponsored by 28 leading engineering, scientific, management and technical organizations. It consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference and the 6th International Atomic Exposition.

Engineers' Wives' Association News

The E.I.C. Wives' Club of Calgary recently awarded its annual $100 scholarship to Clifford David Friesen, a graduate of the Collegiate Institute of Swift Current, Sask. studying engineering at the University of Alberta.

The London section closed the year 1959 with 144 members. A group of members from Woodstock are considering organizing their own group, but for the coming year the program will be chosen and details handled by zone groups.

The Sarnia group pays no membership fee. The membership list is compiled from the E.I.C. membership list which numbers approximately 140 and the wives' membership is estimated at about 125. In the Spring a special meeting is held — usually a tea — to raise a small sum of money for current expenses.

The Toronto Wives' Auxiliary of E.I.C. has established five area groups in lieu of the one large group so that members can become acquainted more easily.

Secretaries for the different sections of the Engineers' Wives' Association for 1959-60 are:

Border Cities — Mrs. J. E. Sinnott, 21 Spring Court, Windsor, Ont.

Calgary — Mrs. J. A. Lamb, 1601 9th Street, N.W., Calgary, Alta.

Cape Breton — Mrs. Gordon W. Ross, 40 Ankerville Street, Sydney, N.S.

Edmonton — (Liaison Member), Mrs. R. C. B. Jarvis, 13211 - 104th Avenue, Edmonton, Alta.

Halifax — Mrs. C. D. Martin, 33 Mumford Road, Halifax, N.S.

Hamilton — Mrs. E. R. Dixon, 16 Wilmar Court, Dundas, Ont.

Kitchener — Mrs. M. A. Montgomery, 162 East Avenue, Kitchener, Ont.

Lakehead—Mrs. Ronald P. Holmes, 1821 Walsh Street, Fort William, Ont.

Lethbridge — Mrs. N. H. Bradley, 2205 - 9th Avenue South, Lethbridge, Alta.

London — Mrs. D. W. Harvey, 33 Croxton Road West, London, Ont.

Manitoba — Mrs. R. O. Jonasson, 51 Rowand Avenue, Winnipeg 12, Man.

Moncton — Mrs. V. C. Blackett, 97 MacBeath Avenue, Moncton, N.B.

Newfoundland (St. John's) — Mrs. F. G. Vivian, 23 O'Reilly Street, St. St. John's, Nfld.

Niagara Peninsula — Mrs. D. O. D. Ramsdale, 157 Highland Avenue, St. Catharines, Ont.

Nipissing & Upper Ottawa — Mrs. R. R. Prescott, Temiskaming, P.Q.

Ottawa — Mrs. G. E. Martin, Apartment 9, 280 Carling Avenue, Ottawa, Ont.

Peterborough: Mrs. T. J. Halme, 455 Albertus Avenue, Peterborough, Ont.

Port Hope — Mrs. H. A. Gadd, 779 Division Street, Cobourg, Ont.

Regina — Mrs. J. S. Anderson, 62 Motherwell Crescent, Regina, Sask.

Sarnia — Mrs. J. C. Harris, 575 Cathcart Blvd., Sarnia, Ont.

Saskatoon — Mrs. W. G. McKay, 413 Hilliard Street East, Saskatoon, Sask.

Sault Ste. Marie — Mrs. V. A. Graham, 135 McMeekin Street, Sault Ste. Marie, Ont.

Toronto — Mrs. G. V. Meagher, 97 Great Oak Drive, Islington, Ont.

Vancouver — Mrs. P. N. Bland, 1996 Trutch Street, Vancouver, B.C.

Victoria — Mrs. O. J. Wilkie, 2046 Carrick Street, Victoria, B.C.

• INTERNATIONAL NEWS

(Continued from page 82)

Silicones Developed to Make Walls Watertight

Scientists in West Germany have a process for treating outer surfaces of houses with silicones to protect them from moisture seepage. They have found that siliconisation of mortar, roughcasting or varnish saves an extra process of silicone application, and that combined with any of these materials the silicones provide six to seven years' protection against water absorption.

Central Air-conditioning Systems for Shopping Centres

A speaker at the recent exposition of the Air Conditioning and Refrigeration Institute in New York stressed the considerable saving which can be made by installing central air-conditioning systems in shopping centres. Initial costs, operating expenses and maintenance charges can all be curtailed. He cited the Southdale Shopping Center in Minneapolis, Minnesota, an 800,000 sq. ft. multi-level structure with two department stores, 70 other shops, and numerous walking and sitting areas, which is entirely enclosed and air-conditioned.

EIC

ANNUAL MEETING

ROYAL ALEXANDRA HOTEL

WINNIPEG

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MAY

25-26-27

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Personals

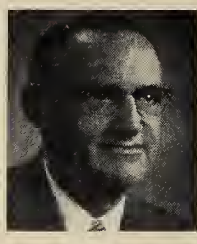
Robert O. King, M.E.I.C. (McGill '95), head of the Defence Research Board's Combustion Research Section, has retired after 65 years of full-time scientific research. Mr. King, who is believed to be Canada's oldest research engineer, will continue his interest in combustion investigations as a consultant to the Board.

For the last ten years Mr. King has been investigating the processes associated with fuel burning in internal combustion engines and has been particularly successful in advancing scientific understanding of these phenomena.

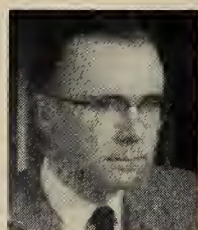
R. W. Diamond, Hon. M.E.I.C., (Toronto '13) has received the highest award of the Association of Professional Engineers of B.C., an honorary life membership, for his distinguished contribution to the engineering profession.

R. W. Diamond, Hon. M.E.I.C.

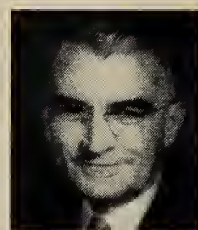
Clement Matthew Anson, M.E.I.C. (McGill '25), a past president of E.I.C., is the new vice-president and general manager of steel operations for the Dominion Steel and Coal Corporation.



C. M. Anson, M.E.I.C.



L. F. Kirkpatrick, M.E.I.C.



S. L. Fultz, M.E.I.C.

A. G. Mahon, M.E.I.C.

Thomas Blench, M.E.I.C. (Glasgow '27), professor of civil engineering at the University of Alberta, has been awarded the degree of Doctor of Science by that university.

Dr. A. Hartley Zimmerman, chairman of the Defence Research Board, presents Robert O. King, M.E.I.C., retiring head of the board's Combustion Research Section, with a bound volume of scientific papers published by Mr. King and his associates.

L. F. Kirkpatrick, M.E.I.C. (Nova Scotia '38) has been appointed manager of the Nova Scotia Power Commission. **S. L. Fultz**, M.E.I.C. (Nova Scotia '20) is the new administrative assistant and **A. G. Mahon**, M.E.I.C. (Nova Scotia '29) succeeds Mr. Fultz as director of operations.

W. L. Wardrop, M.E.I.C. (Manitoba '39) took over the presidency of the Canadian Institute on Sewage and Sanitation in October. He is also president of the Manitoba Association of Professional Engineers and chairman of the Winnipeg branch of E.I.C.

S. M. Breuning, M.E.I.C. (Stuttgart '49) has accepted a position as associate professor of civil engineering with Michigan State University in Lansing, Mich. He will teach and do research in connection with the Highway Traffic Safety Center.

(Continued on page 90)

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We hope that two of the Institute's more distinguished Honorary Members, John Bertram Stirling, Hon. M.E.I.C. and L. Austin Wright, Hon. M.E.I.C., will forgive our apparent disregard of their proper names and designations. This was a most regrettable consequence of haste in the preparation of the December issue.

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• PERSONALS

(Continued from page 88)

Lt.-Col. Donald H. Rochester, M.E.I.C. (Toronto '41) has been made chief of the Canadian section, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas. Canada has not been represented on the faculty of the college previously.

Lt. Col. D. H. Rochester, M.E.I.C.

John Renchko, JR.E.I.C. (Saskatchewan '49) is employed with Emerson-Day, Niagara Falls, New York, as electrical engineer on construction of the Niagara Switchyard power project.

Donald C. Cullingham, M.E.I.C. (Toronto '50) has been appointed process engineer at the new MgO process dissolving pulp mill in Sitka, Alaska.

S. K. McMillan, M.E.I.C. (Saskatchewan '50) is now employed as mechanical superintendent, architectural branch, Department of Public Works, Province of Manitoba, with residence in Winnipeg.

James R. Wallace, JR.E.I.C. (Alberta '52) has been appointed chief metallurgist for the Dominion Steel and Coal Corporation's steel operations from Montreal to Aguathuna, Newfoundland.

J. A. Walsworth, JR.E.I.C. (Queen's '53) has left Canadian Westinghouse to take a position with Dupar Canada Limited in Kitchener, Ont.

Donald M. Onysko, JR.E.I.C. (Manitoba '57) is working for T. Lamb, McMannus and Associates Ltd. in Winnipeg after two years in England on an Athlone Fellowship.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Address all information to: *The Engineering Journal,* Editorial, 2050 Mansfield Street, Montreal, Que.

NEWS OF THE BRANCHES

Assumption University

William Pulleyblank, S.E.I.C.,
Correspondent

William Arison, M.E.I.C., past chairman of the board of directors of Essex College and assistant production manager of Hiram Walker & Sons Ltd., Walkerville, Ontario, spoke to students at a dinner on November 28 forecasting what the first graduating class in engineering at Assumption University should expect from industry.

A dance followed the dinner and students and faculty had a most enjoyable evening. The idea of a dinner-dance to make students and faculty become better acquainted is likely to become an annual affair.

Belleville

D. A. Law, JR.E.I.C.,
Correspondent

Mr. Joseph Steven of Ontario Hydro's planning department outlined the growth of his company from the early 1900's to the present at the December 7 meeting. In 1910, he pointed out, Ontario Hydro was serving eight municipalities. Today it is the second largest power utility in North America. Mr. Steven explained that today's peak loads are being met by supplementing hydraulic installations with thermal power.

Border Cities

R. L. Kennedy, JR.E.I.C.,
Correspondent

About 55 branch members heard a panel discuss the erection of the Princess Margaret Bridge in New Brunswick on November 19. Victor Davies, M.E.I.C., of Dosco, chaired the panel which included Walter Macdonald, Jr.E.I.C., and Dick Cranker, M.E.I.C.

Calgary

Herbert Bailey, M.E.I.C.,
Correspondent

City Traffic Supervisor Robert Bailey spoke to members on November 3, discussing the chronic traffic difficulties with which Calgary is faced. He showed graphs of traffic patterns which had been made following 1,000 interviews and also presented maps indicating the future system of freeways and throughways through the city. He suggested that Calgary may before long see elevated pedestrian crosswalks at major intersections, particularly over one-way streets. A series of graphic, colored photographs of traffic accidents brought about a lively discussion of traffic control safety in the city.

Cape Breton

Harold M. Aspinall, M.E.I.C.,
Correspondent

Sir Charles Goodeve, director of the British Iron and Steel Research Association, London, spoke to Cape Breton members at a meeting in the Isle Royale Hotel, Sydney, on November 30. He described the tonnage oxygen development and L.D. steel processing as revolutionizers of today's industry but pointed out that the process still had one sizable disadvantage. The extensive fuming which occurs, he explained, necessitates the use of costly cleaning equipment.

Central B.C.

A. F. Joplin, M.E.I.C.,
Correspondent

Mel J. Shelly, M.E.I.C., was elected chairman of the branch on November 27. Serving with Mr. Shelley on the executive will be H. A. Price, J. W. Nelson, R. C. Wannop, E. R. Gayfer and B. Harvey.

Mr. P. Tassie, retiring chairman of the branch, reviewed the year's accomplishments and singled out the completion of the memorial cairns erected by the Central B.C. branch to the memory of our pioneer engineers and the field trip through Rogers Pass as the outstanding events of 1959. Following the dinner, Mr. Bruno Engler, a professional photographer for the Trans Canada Highway, showed films of mountain work in the vicinity of Banff.

Chalk River

G. R. Fanjoy, JR.E.I.C.,
Correspondent

Members heard Professor K. B. Jackson, head of the department of applied physics, University of Toronto, give a talk on photogrammetry, November 3. Research into the question of how much information can be gleaned from these photographs has occupied much of Professor Jackson's time. He showed several pictures of the model which he built for photographing from the air. From these photographs he is able to check resolution, colour graduation from white to black, and the effect of haze on shadows produced.

St. Dunstan's University (Charlottetown)

Francis S. S. Tam, S.E.I.C.,
Correspondent

On October 30 the third year engineering students accompanied by Mr. D. Kawaja, Jr.E.I.C., faculty representative, went to Halifax to visit the Nova Scotia Technical College. They were met by faculty and students of N.S.T.C. and shown the different buildings and departments. The detailed explanations from both faculty members and senior students contributed to one of the most interesting educational tours that St. Dunstan's students have had.

Francis S. S. Tam, S.E.I.C., was elected student representative to E.I.C. at the November 4 meeting.

Cornwall

H. S. Johnston, JR.E.I.C.,
Correspondent

J. L. Olsen of the civil atomic power section of Canadian General Electric gave members a review of the nuclear energy business on November 17. He explained that a program of nuclear power plant development is under way, sponsored jointly by the Canadian government, Ontario Hydro and Canadian General Electric. Mr. Olsen stated that nuclear power plants are economically competitive now with coal and oil-fired plants but require approximately five to seven years' development work to overcome operational problems.

Corner Brook

H. A. Hinton, JR.E.I.C.,
Correspondent

On Wednesday evening, November 25, members were taken on a conducted tour of the recently opened CBC radio and television station here. Besides demonstrating the modern equipment, staff members answered many questions on operation of the station.

Fredericton

John Burrows, JR.E.I.C.,
Correspondent

The November joint meeting of the Fredericton branch of E.I.C. and members of the Association of Professional Engineers of the Province of New Brunswick was held on November 16 in the banquet rooms of The Paradise Restaurant. Dr. R. B. Banerji of the department of engineering and mathematics, University of New Brunswick, spoke to the group on electronic computers.

Hamilton

Charles A. McCurdy, JR.E.I.C.,
Correspondent

The first dinner meeting of the 1959-60 season was held at the Argyle and Sutherland Highlanders Officers Mess where the famous hot roast beef and mushroom gravy dinner was served in buffet style. L. C. Sentance, M.E.I.C., manager of the Atomic Energy Division of the Canadian Westinghouse Co., gave an illustrated lecture on atomic marine propulsion.

The chairman announced the formation of a new group within the branch, the "Civils Group", open to all members who are interested in any aspect of civil engineering. Their first meeting will be on winter construction, January 14.

President J. J. Hanna visited the branch on January 22 and presented his report on E.I.C. affairs. The ladies were present and a buffet luncheon and entertainment by the Hamilton Theatre Guild followed the president's talk.

Kingston

D. I. Ourom, JR.E.I.C.,
Correspondent

"Some Applications of Modern Computer Techniques" was the title of a speech given by Mr. Radford, director of systems evaluation at R.C.A.F. Headquarters in Ottawa, on November 17.

Kitchener

John F. Runge, M.E.I.C.,
Correspondent

I. Needles, chairman of the board of directors of B. F. Goodrich Canada Ltd., gave an outstanding general talk at the November 3 meeting about the engineer in industry and his opportunities for advancement to management and executive positions.

Although some engineers in their present positions are limited in seope, Mr. Needles maintained, they have every chance to gain experience in public speaking, accounting, salesmanship and administration by taking part in community and service club functions.

Kootenay

Ian Waterlow, JR.E.I.C.,
Correspondent

Mr. E. Rohatynski, Jr.E.I.C., liaison engineer with Cominco's iron and steel project, read a paper on "Model Studies leading to Modification of Waneta Dam" at the November 19 meeting. The paper, presented at the Western Zone Technical Conference, dealt with changes made in the No. 1 Spillway of the Waneta Dam brought about by extensive studies of the flow and jump pattern on the spillway outflow.

Lakehead

G. O. Hanson, JR.E.I.C.,
Correspondent

Members visited the central control system of the Canadian National Railways on the evening of November 18. Vern McGregor, signals department engineer, gave an illustrated talk on the growth of railroad signal systems from the early days of hand signals up to the present situation where one dispatcher can control trains 400 miles way. He noted that the installation at the Lakehead, controlling the movement of trains from here to Atikokan, is typical of modern installations.

Loyola (Montreal)

The Dominion Steel and Coal Company in Verdun, Que., was host to our group on November 25. Students were impressed by the vastness of the 25-acre plant but were glad to find an excellent ¼" to 1' scale model in the plant office for an appreciation of the general layout of the building. Safety is an important consideration in the Dosco works and students were given special safety glasses before starting the tour of the plant.

University of Manitoba

D. W. Brown, S.E.I.C.,
Correspondent

The membership drive held from November 2 to 6 resulted in approximately 190 new members.

Each Thursday films are being presented in the noon hour at the Engineering Building. About 200 student engineers have attended these sessions.

McGill University (Montreal)

R. D. Hatfield, S.E.I.C.,
Correspondent

One hundred and fifty-five engineering students became S.E.I.C.'s in the Fall drive for membership.

The Montreal branch Students' Night, January 27, will completely change its pattern this year. Included in the technical papers' competition will be delegates from Laval and Sherbrooke Universities. The McGill organizing committee expects to have an E.I.C. member address the students on the function of E.I.C.

Moose Jaw

T. L. Salmon, M.E.I.C.,
Correspondent

J. A. Beveridge, city commissioner of Moose Jaw, discussed the five-year development plan for the city on November 18.

Officers for 1959-60 elected at the meeting are: H. Kindred, chairman; J. MacKay, vice-chairman; T. L. Salmon, secretary-treasurer; and R. Grant, member of the executive.

Saguenay

Maurice Lavallee, JR.E.I.C.,
Correspondent

The November 3 meeting of the Saguenay branch, to which members of the Corporation of Professional Engineers of Quebec and the Chemical Institute of Canada were invited, was addressed by Dr. J. M. Zarzycki. Dr. Zarzycki is chief engineer of the Engineering Services Division of Canadian Aero Service Ltd. and he spoke on "Photogrammetry in Engineering and Science".

At the general meeting on November 27, held at the Saguenay Inn, Arvida, members had the honour of hearing President Hanna talk about his recent tour through Canada. Mr. Hanna recommended that engineers should give more attention to economic and financial conditions and suggested a program of education toward this end.

Saint John

Harley K. Larsen, JR.E.I.C.,
Correspondent

James E. Isbester, resident engineer of H. G. Acres Co. Ltd., consulting engineers on the East Saint John thermal power plant, spoke to members on December 8 on his experiences working in Pakistan under the Colombo Plan.

The following were elected to the executive for the coming year: J. B. Eldridge, chairman; P. W. Hastings, vice-chairman; J. P. Mooney, secretary treasurer; Gordon Bayne and M. C. Schofield, councillors.

(Continued on page 103)

OBITUARIES

L. MacC. Allison, M.E.I.C., of Armdale, Nova Scotia died on September 24, 1959. Mr. Allison was associated for many years with the Department of Public Works of Canada and worked on many of the larger public works projects in Nova Scotia from 1924 until his retirement in 1957.

Born in Halifax in 1892, Mr. Allison received his engineering education from Dalhousie University and graduated from that institution in 1911. He began his career with the Department of Railways and Canals on railway construction and in 1920 and 1921 worked on the Saint Lawrence Improvement Survey.

In 1924, after two years with the Nova Scotia Provincial Highway Board, Mr. Allison entered the Federal Department of Public Works. As area engineer for Lunenburg, Queens, Shelburne and Yarmouth counties in Nova Scotia, Mr. Allison contributed to a great variety of construction projects.

Harry Holborn Angus, M.E.I.C., past president of the Association of Consulting Engineers of Canada and head of two Canadian engineering firms, died in Toronto on November 3, 1959.

Mr. Angus was born in London, Ontario and graduated from the University of Toronto in 1904. Before organizing his own consulting business in Toronto in 1922, he worked with Bethlehem Steel, Westinghouse and Western Electric in the United States.

As president of H. H. Angus and Associates Ltd., Toronto, and Angus, Butler & Associates, Edmonton, Mr. Angus gained widespread recognition through his work on many commercial buildings and hospitals, among them the Toronto General.

He was a past chairman of the Ontario section, American Society of Mechanical Engineers and a life member and past chairman of the American Society of Heating and Ventilating Engineers.

Morris A. Bohn, JR.E.I.C., has died at the engineers' camp of B.C. & B.B. Power Consultants in British Columbia.

Mr. Bohn, who obtained his civil engineering B.Sc. at Queen's in 1957, joined the Institute as a student that year. He subsequently worked as a research assistant in the department of civil engineering at the University of Illinois.

Frank Charles Graham, M.E.I.C., city engineer at Port Arthur, Ontario, died on November 20, 1959. He was 68.

Mr. Graham was born in Broadview, Saskatchewan. In 1907 he came to Port Arthur and began work in the city's engineering department. For 47 years he

L. M. Allison, M.E.I.C.

A. A. Murphy, M.E.I.C.

H. M. Olssen, M.E.I.C.

worked in this department and in 1954 he retired as city engineer.

A past chairman of the Lakehead Branch of the Institute, Mr. Graham was granted Life Membership on January 1, 1957.

Harry Louis Hayne, M.E.I.C., a Life Member of the Institute, died suddenly on September 7, 1959.

Construction work for the Canadian Pacific Railway in the West was the first engineering assignment for Mr. Hayne, whose birthplace was London, Ontario. From 1910 to 1912 he was resident engineer for construction on the Esquimalt & Nanaimo Railway, and on his return from overseas service he worked for this line again until 1921. That year Mr. Hayne joined the British Columbia Department of Public Works, and when he retired twenty-nine years later he was its chief construction engineer at Kamloops.

Mr. Hayne joined the Institute in 1920 as an Associate Member, and was active in the Central British Columbia Branch from the time of its inauguration. In 1950 he was elected to represent this branch on the Council, and his Life Membership was conferred four years later.

James Frederick Lester M.E.I.C., a member of the Institute for thirty-nine years, died on October 10, 1959.

Mr. Lester had retired only two months earlier after a long and varied career as a professional engineer. His service with the Canadian Pacific Railway as a construction engineer from 1911 to 1934 was interrupted only by a period overseas with the Canadian Army. In 1934 Mr. Lester joined the Ontario Department of Highways as resident and location engineer. The Second World War took him overseas again, and after serving with the Air Ministry in Britain as resident engineer and works officer on airport and ancillary works, he remained in England on various civil engineering construction projects for Sir Robert McAlpine & Son Limited.

In 1948 Mr. Lester returned to this country and joined the Alberta Department of Highways. He was appointed Chief Location Engineer when the location branch was formed in 1953.

Adelbert Arthur Murphy, M.E.I.C., died on December 2, 1959 at the age of 75. A recognized leader in Canadian broadcasting, Mr. Murphy established CFQC Radio in Saskatoon in 1923 and just five years ago, in 1954, CFQC-TV.

Born in Portland, Ontario in 1884, Mr. Murphy earned science degrees from both Queen's and McGill Universities. He was a partner in a firm of Saskatoon consulting engineers from 1911 to 1920 and then spent two years in the electrical business before establishing his radio station.

In 1936 Mr. Murphy was vice-president of the Canadian Association of Broadcasters. He also served as president of the Western Association of Broadcasters.

Harald Matias Olsson, M.E.I.C., died on October 19, 1959 in Port Arthur, Ontario. He was 61. Born in Sweden in 1898, Mr. Olsson was educated in Sweden and Germany and came to Canada in 1925.

Mr. Olsson's first employment in Canada was with the Canadian National Railways in Winnipeg. In 1926 he went to work as a draughtsman for the Dominion Bridge Company and later in that same year joined the staff of the C. D. Howe Company in Port Arthur, Ontario.

In 1946 he was made their chief engineer and in 1950 became manager of the Port Arthur office, which post he held until the time of his death. The design of grain terminals in Port Arthur, Sas-

(Continued on page 103)

News of Other Societies

R.C.E.M.E. Corps. Celebrates 14th. Year

The R.C.E.M.E. School at Barriefield, Ontario was the meeting and dining place for the Royal Canadian Electrical and Mechanical Engineers Corps Association on October 24. Seventy-five members from across Canada attended the meeting and heard speeches by Lt. Col. F. N. Pope, acting director of militia and cadets, and Col. R. A. Campbell, director of the Corps. Officers elected for the 1959-60 term are: president, Lt. Col. E. D. Gray-Donald (Montreal); first vice-president, Major A. Anderson (Hamilton); secretary-treasurer, Lt. Col. LeSueur Brodie (Toronto).

Professor John Dunbar of McGill University's zoology department addressed 150 members at the dinner on "Problems and Prospects of the Canadian Arctic".

An illuminated scroll honouring the memory of the late Colonel H. G. Thompson was presented to Mrs. H. G. Thompson by Lt. Col. A. G. Edward of Montreal on behalf of the Royal Canadian Electrical and Mechanical Engineers Corps Association. A past executive assistant general secretary of E.I.C., Mr. Thompson organized the R.C.E.M.E., served as its president for three years, and was active in it until his death.

American Institute of Chemical Engineers

Jet and rocket combustion, heavy water production, pulp and paper processing, electrochemical equipment and liquid purification by solvent extraction—these are but a few of the subjects dealt with at the annual meeting of the American Institute of Chemical Engineers in San Francisco on December 6-9.

The Society of Petroleum Engineers joined in sponsoring three sessions on petroleum recovery methods, underground combustion and displacement by liquefied hydrocarbon gases.

Institution of Electrical Engineers, Britain

The Impact of Nuclear Development on Electricity Supply and on Instrument Techniques is the theme for the September 1961 Convention which is to be organized by the Measurement and Control Section of The Institution of Electrical Engineers, London.

The organizing committee will be pleased to receive offers of papers which might be included in the Convention's program.

Gas Dynamics Colloquium, 1959-60

The Department of Mechanical Engineering of The Technological Institute at Northwestern University, Evanston, Illinois is sponsoring a colloquium on gas dynamics from October 15, 1959 to May 26, 1960. The schedule for the next month reads: Feb. 4—Steady State Magnetohydro-dynamic Experiments; Feb. 11—Departures From Equilibrium in Mixing Regions; Feb. 18—Relaxation Times in Gases; Feb. 25—A New Application for the Hydraulic Analogy.

1961 Congress of Chemical Engineering

The 13th Exhibition Congress of Chemical Engineering organized by the DECHEMA will be held in Frankfurt from June 9 to 17, 1961. It will include the following groups of exhibits: research and literature, new chemical substances, nuclear science and techniques, laboratory techniques, measurement control and automation techniques, structural materials techniques, works mechanics, pumps and fittings, packaging techniques, auxiliary materials and consumable stores, accident prevention and works safety precautions.

World Conference on Earthquake Engineering

The Science Council of Japan in cooperation with the Japan Society of Civil Engineers, the Architectural Institute of Japan, and the Seismological Society of Japan is planning a second World Conference on Earthquake Engineering, to be held in Tokyo and Kyoto, Japan on July 11-18, 1960.

National Concrete Products Manitoba Conference

The National Concrete Products Association will hold its annual convention in Winnipeg on January 18-20, 1960. Indicative of the growing potential of the association is the fact that this is the first time in its eleven-year history that the convention has been held outside Quebec and Ontario.

Coming Events:

Conference on Automatic Computing and Data Processing in Australia

Sponsored by The Australian National Committee on Computation and Automatic Control
The Universities of Sydney and New South Wales
May 24-27, 1960.

Symposium on Plastics in Domestic Refrigeration

Presented by The Society of the Plastics Industry, Inc.
Dallas, Texas
February 1-4, 1960.

International Congress of Scientific Management

Organized by the International Committee of Scientific Management
Sydney, Australia Session: February 22-26, 1960.
"Management Methods in the Next Decade"
Melbourne, Australia Session: February 29 to March 4, 1960.
"Management in a Developing Country".

1960 Pacific Northwest Metals and Minerals Conference

Sponsored by The American Institute of Mining, Metallurgical and Petroleum Engineers
Portland, Oregon
April 28-30, 1960.

Seventh Commonwealth Mining and Metallurgical Congress

Union of South Africa, Northern and Southern Rhodesia
April 10 to May 21, 1960.

Conference on Coastal Engineering

Council on Wave Research of the Engineering Foundation (USA) and the Rijkswaterstaat of the Netherlands
The Hague, Netherlands
August 22-27, 1960.

Third International Conference on Nondestructive Testing

Organized by the Science Council of Japan in cooperation with the Japanese Society for Nondestructive Inspection
Tokyo: March 15-18, 1960.
Osaka: March 21, 1960.

LIBRARY NOTES

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

UNEMPLOYMENT: THE PROBLEM OF INDUSTRIAL NATIONS

The author, a member of the Engineering Institute of Canada, has compiled this volume largely from material presented to the Montreal Branch in the past. He presents his views on the causes of unemployment, superfluous manpower created by the harnessing of the forces of nature, and the boom and depression cycle, and considers ways of combatting this by social, fiscal, tax and monetary reform. (P. Ackerman. Montreal, the author, 1959. 75p., $4.00. Special price to E.I.C. members $2.50.)

GATEWAY TO THE WORLD

A pictorial record in photograph and water-colour of the construction of the St. Lawrence Seaway, both the ship canal and the power project. Mr. van der Aa has taken some wonderful photographs, and the descriptive text by Donald M. Ripley, a member of the Institute, provides enough information to place them in their context. (Hans van de Aa. Montreal, Robson Printers, 1959. 184p., $3.95 hard cover, $2.50 soft.)

THE MODERN SLIDE RULE

In this description of his new method of using the slide rule, by which the position of the decimal point is fixed exactly in all operations, without approximate calculations having to be made, the author lists all the operations which can be performed with a slide rule, and explains how they are done. (Stefan Rudolf. New York, William-Frederick, 1959. 68pp., $5.00.)

LES ENERGIES DE LA MER

The recent report on the Passamaquoddy power project increases the interest of these proceedings of a conference held in 1956 on energy from the sea. The papers are divided into eight groups, covering: the natural state of the mechanical energy of waves and tides; scale model tests of the mechanical energy of waves and tides; harnessing tidal and wave energy; harmful effect of waves and tides, tidal bores, etc., and protective structures; utilization of the sea's thermal energy, the equipment used and general conclusions. (Grenoble, la Houille Blanche, 1958. 2 vols., no price given.)

*MODERN AIR CONDITIONING, HEATING AND VENTILATING, 3rd ed.

This edition presents a thorough revision of all chapters where significant advances have been made in the past decade. Additions to the volume include a section on psychrometric processes, new material on factors influencing comfort, and an expanded treatment of basic cycle theory. Also added are a section on high-velocity air duct design and a chapter on industrial systems. Volumetric efficiency, work and horsepower receive a more theoretical treatment, while the chapter on the heat pump has been expanded and given more rigorous theoretical treatment. The appendix includes many new tables such as solar azimuth angles and intensity data, summer degree-days for cooling, and properties of refrigerants 113 and 500. (W. H. Carrier and others. Toronto, Pitman, 1959. 592p., $12.00.)

*STEAM TURBINE OPERATION, 6th ed.

Thermal and mechancial considerations which effect the operation and handling of larger steam turbines are described. Topics discussed include installation, heating and drainage of turbines, lubrication, thrust bearings and their adjustment, governors and governing, starting and stopping of turbines, inspection and overhauling, regenerative feed-heating, erosion of blading in low-pressure stages, supervisory and protective equipment for turbines, and turbine testing. (W. J. Kearton. Toronto, Pitman, 1958. 453p., 35/-.)

*TELEGRAPHY

The theory and principles of telegraphy upon which practical systems and equipment are based is explained. Detailed information is given on the equipment used by the British Post Office for its inland and oversease public telegraph services and for private wires and telex. Aspects discussed are electromagnetic relays, line plant, manual switching telegraph systems, automatic switching of telegraph circuits, multi-channel voice-frequency systems, start-stop instruments, facsimile and picture telegraph systems, teleprinter private wires and telex service, and submarine cable telegraphy. (J. W. Freebody. Toronto, Pitman, 1959. 738p., 80/-.)

*FUELS AND LUBRICANTS

Summarizing material from a great many sources, the authors discuss the important fuels, including boiler, internal combustion engine, and jet fuels, as well as rocket propellants and nuclear fuels. Emphasis is placed on the correlation between the properties of fuels and lubricants and their performance in an engine or machine, as well as on the significance of the standard tests that are conducted on these materials. Particular features of the volume include discussions on synthetic lubricating oils, and a tabulation of octane numbers of many pure hydrocarbons. (M. Popovich and C. Hering. New York, Wiley, 1959. 312p., $8.50.)

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THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

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● LIBRARY NOTES

(Continued from page 96)

*FUNDAMENTALS OF ELECTRON DEVICES AND CIRCUITS

Survey of electron devices that gives an analysis of newer devices such as transistors, diodes, and magnetic amplifiers as well as conventional vacuum and gas tubes. A thorough analytical approach stressing physical phenomena is used where possible. Topics discussed include electron emission and acceleration; single-phase and poly-phase rectifiers; diodes, triodes, and multigrid tubes; class A amplifiers; push-pull and feedback amplfiers; transistor circuits; magnetic amplifiers; gaseous tube circuits; controlled rectifiers and inverters; regulators; operational amplifiers, and oscillators. (N. R. Wood and W. L. Davis. Englewood Cliffs, Prentice-Hall, 1959. 591p., $9.50.)

*BALL AND ROLLER BEARINGS

Translated from the German edition, this book represents the experience of a large ball and roller bearing company. The types, materials, dimensions, and tolerances of the important bearings manufactured in Europe are presented. This is followed by a discussion of bearing stresses and kinematic phenomena with consideration of the basic relationships between carrying capacity, load, and life. A series of individual problems is then used to illustrate design principles and the practical aspects associated with them. (P. Eschmann and others. London, Heyden, 1958. 375p., $8.75.)

*APPLIED HYDRODYNAMICS

A practical approach to the theory of hydrodynamics which stresses the adaptation of non-viscous flow theory to the analysis of real, or viscous, fluid flow. Topics discussed include flow of an ideal and a real fluid; graphical flow nets, numerical analysis, and experimental analogies; standard patterns of flow; conformal transformation; and three-dimensional irrotational flow. Emphasis is paid in the text to detailed physical explanations of such concepts as stream functions, potential function and conformal transformation. (H. R. Vallentine. Toronto, Butterworth, 1959. 272p., $10.00.)

*INTRODUCTION TO THE DYNAMICS OF FRAMED STRUCTURES

Using two mathematical tools, matrices and orthogonal functions, the author presents the analytical aspects of dynamic disturbances in structures. Lumped parameter and distributed parameter systems are discussed, and the classical formulation of problems based on direct application of Newton's laws of equilibrium are considered. Particular applications dealt with include stresses and strains in structures during and after earthquakes and atomic blasts, action of moving loads such as highway and railroad bridge loadings, deflections and bending movements, and velocities and shear forces in structures acted upon by dynamic disturbances. (G. L. Rogers. New York, Wiley, 1959. 355p., $10.25.)

*SYMPOSIUM (INTERNATIONAL) ON COMBUSTION, SEVENTH, 1958

A comprehensive survey that begins with detonation, and in particular the transition from flame propagation to detonation. It continues with spectroscopy and the structure of flames in which modern methods of following the change of composition through a flame front are described. A substantial part of the book is then devoted to the mechanism of combustion reactions, both hydrocarbons and other substances being considered. Also investigated are ignition and limits of inflammability, combustion in practical flowing systems, special fuels, and instrumentation. (Toronto, Butterworth, 1959. 959p., $28.00.)

*MASERS

A study of quantum mechanical amplifiers that approaches the subject from both the classical and quantum mechanical points of view. Beginning with a discussion of the ammonia maser and of the magnetic atomic beam system, there is a section on an optically pumped frequency standard and a description of electron paramagnetic resonance. Two level masers are then treated with emphasis on their possibilities for millimeter and submillimeter wave generation, and numerical illustrations are employed in an examination of three level cavity masers. The book concludes with the theory and experimental results of the travelling wave masers. (J. R. Singer. New York, Wiley, 1959. 147p., $6.50.)

PULP AND PAPER MANUAL OF CANADA, 1959

This twenty-seventh edition follows the same plan as previous ones. The first section contains general information on the industry in Canada, the second contains brief technical articles, this year on cost reduction techniques, the third lists mill operating personnel and gives flow sheets for pulp and paper mills, and the last section is a classified buyers' guide. (Ed. by J. N. Stephenson. Gardenvale, National Business Pubs., 1959. 480p.)

SURVEY OF INDUSTRIALS, 1959

Hundreds of companies covering all types of Canadian industry are reviewed in this edition. The information given for each includes earning statements and balance sheets, working capital position, dividend history, funded debt, directors and subsidiaries. The price range of Canadian stocks over the last eight years is included. This is a valuable reference tool. (Toronto, Financial Post, 1959. 400p., $4.00.)

NATIONAL REFERENCE BOOK, 1959-60

Almost 1300 biographies of Canadians prominent in the commercial field are included in this new edition, many of them being accompanied by photographs.

The second section of the volume contains useful information about Canada, including geography, national parks, government, sources of official information, population, a business directory, and a classified index to the biographies. (L. M. Durant, ed. Montreal, Canadian Newspaper Service, 1959. 1707pp., no price given.)

FRASER'S CANADIAN TRADE DIRECTORY, 1959

In this 46th edition of an invaluable directory, 10 percent of the brand and trade names appear for the first time. Over 12,500 firms are listed alphabetically, and their products shown under 6,500 headings. Over 12,000 foreign companies and their Canadian representatives are listed.

The market section contains valuable data for those companies interested in foreign trade, as well as a list of cities and towns over 2,000 population, transportation companies, utilities, banks, telephone and telegraph companies etc. (Montreal, Fraser's, 1959. 1880pp., $10.00.)

CANADIAN TRADE INDEX, 1959

The major section of this index is a classified list of Canadian products and their manufacturers, with a French index. There is an alphabetical listing of over 11,000 Canadian manufacturers, a section of information for exporters, and a produce section. (Toronto, Canadian Manufacturers' Association, 1959. 1071p., $12.50.)

*AUTOMATION TODAY AND TOMORROW

The field of automation is surveyed and some of its important aspects are described. These include sales and distribution, building design, computer control of processes, instrumentation in the process industries, processing methods and automatic assembly, industrial finishing, and inspection and testing. In addition, automation in specific industries is discussed, and an extensive bibliography is provided which includes references to books and articles covering many of the advances in automation. (L. L. Goodman. London, Newman Neame, 1958. 158p., £2.)

*PROCESS EQUIPMENT DESIGN: VESSEL DESIGN

The basic concepts, industrial practices, and theoretical relationships useful in the design of processing equipment are presented with particular reference to pressure vessels. Beginning with a review of elementary theories of mechanics and strength of materials, the material covered ranges from simple vessels for low pressure service to thick-walled vessels for high pressure applications. Advanced theory is developed as needed and is integrated with design practice. (L. E. Brownell and E. H. Young. New York, Wiley, 1959. 408 p., $18.00.)

*RIVER POLLUTION. 1: CHEMICAL ANALYSIS

The present volume constitutes an expansion of chapters 9 and 10 of the author's previous work "Aspects of River

(Continued on page 104)

Employment Bulletin No. 60-1

EMPLOYMENT SERVICE

SITUATIONS WANTED

CIVIL ENGINEER, Jr.E.I.C., M.S. Princeton 1952, B.Sc. London 1951. Age 29, married, one child. Desires structural design position with consulting engineer. Particularly interested in prestressed concrete. 3 years experience at site of construction of large hydro-electric development. 1½ years experience in structural design for industrial plant buildings. Present location Quebec. Prefers to remain in Eastern Canada. Available on reasonable notice to present employer. File No. 5610-W.

M.B.A. AND MECHANICAL ENGINEER. Postgraduate M.B.A. from U.S. University 1956, B.Eng., mechanical McGill 1954, Jr.E.I.C., P.Eng., age 28, single. Three years experience conducting studies preparing reports for senior management on economic appraisals of process, plant expansions, development of production, distribution costs, market research, budget preparation. Seeking position where strong analytical ability together with engineering and economics background is needed. Speak French. Will relocate. Complete resume on request. Located Central Canada. File No. 5638-W.

SENIOR PROFESSIONAL ENGINEER, M.E.I.C., specializing in project engineering, production planning, production set-up design, methods, work simplification. Production administration and management. Location in or around Toronto preferred. Located Central Canada. File No. 5642-W.

CIVIL ENGINEER, M.E.I.C., P.Eng., (Ont.) B.A.Sc. University of Toronto 1948. Age 33, married with family. Twelve years experience in construction industry, six in field and six in office management position. Available for management position with an excellent future. Present location Southern Ontario. File No. 5663-W.

MECHANICAL ENGINEER, P.Eng., Jr.-E.I.C., Grad. I. Mech. E., age 28. Experience includes five years comprehensive training rubber industry. Special purpose machine design, plant layout, two years gas turbine, fuel equipment. Also project and field engineer on diversified hydraulic schemes, construction and research. Presently design, estimate engineer, plumbing, heating, ventilating systems. Seeks permanent position in small or medium development organization. Presently located Central Canada. File No. 5683-W.

HYDRO ELECTRIC ENGINEER, P.Eng., M.E.I.C., B.Sc., London 1952. Age 39, with seven years experience in the electrical and mechanical aspects of the design, construction, contract administration, operation, and maintenance of large hydro electric stations, seeks responsibility for the contract administration of a hydro project with consulting engineers or utility, at home or abroad. Located Central Canada. File No. 5685-W.

MECHANICAL ENGINEER, Jr.E.I.C., B.Sc. Queen's 1948, veteran, age 41, married with family. Experience since graduation five years plant engineering and six years welding engineer with a firm producing medium heavy custom fabrications including unfired pressure vessels. Wishes to continue in the welding field. Located South East Ontario but prepared to relocate preferably Eastern Ontario or Montreal area. Immediately available. File No. 5717-W.

MECHANICAL ENGINEER, M.E.I.C., P.Eng. Age 35, married. Graduate of University of Toronto. 10½ years experience in the pulp and paper industry. Wish to relocate with a progressive manufacturing company or enter sales and service field. Montreal area preferred. Located Central Canada. File No. 5718-W.

CIVIL ENGINEER, P.Eng. (Que). Jr.E.I.C., B.Eng., in applied mechanics McGill 1957. 2 years experience in systems analysis and evaluation. Age 25 years, single. Seeking employment in mechanical or structural field, preferably in a research and development role. Located Atlantic Province. File No. 5719-W.

CIVIL ENGINEER, Jr.E.I.C., P.Eng. (Ont.) age 37. Nine years field and office experience in heavy and general construction. Experience includes municipal works, hydro projects, townsite and subdivision construction, radar and microwave projects, highway construction and industrial construction. Three years professional Development Course of the E.I.C. Interest lies in municipal or general engineering administration. Resume on request. Located Central Ontario. File No. 5720-W.

CIVIL ENGINEER, P.Eng., M.E.I.C., age 44, with extensive experience in senior administrative posts in municipal engineering in Canadian Cities, and in the design and construction of major arterial roadways, sewers, drainage systems and water works. Seeks challenging position with a consultant firm in the Maritimes or Eastern Canada. Located Central Canada. File No. 5721-W.

CHEMICAL ENGINEER, B.Sc.Ch.E., 1942, M.E.I.C., M.A.I.Ch.E. Seventeen years experience process, project and sales engineer for petroleum refineries and petrochemical plants. Perfect German, some Dutch and Russian. Presently in Europe as Project Manager. Seeks senior position in Vancouver with engineering, petroleum refining, or petrochemical company. Located W. Germany. File No. 5722-W.

ELECTRICAL ENGINEER, M.E.I.C., P.Eng. (Ont.) McGill 1951, married. Diversified experience includes; CGE Test Course; electrical manufacturing, plant engineering; consulting and project engineering in the chemical, industrial and commercial fields. Seeking a responsible industrial job where this experience can be effectively utilized. Preferred location Ontario. Located Central Canada. File No. 5723-W.

YOUNG CANADIAN MECHANICAL ENGINEER, Jr.E.I.C., (age 26, single) presently being turned into an organization man by a large Montreal aircraft manufacturing firm, wants to get off the design board and do some active work requiring a P.Eng., fluent bilingualism, imagination, individuality, and a liking for travel. Prefer Montreal as base of operations. Four years of Canadian and British industrial experience. Located Central Canada. File No. 5725-W.

CIVIL ENGINEER, P.Eng., (Alta.) B.Sc., A.R.C.S.T. Jr.E.I.C., (University of Glasgow) 1951, age 30, professional experience with Canadian consulting engineers in structural design, completed course requirements for Master's degree 1958 (structures, soils), at present on graduate scholarship and teaching assistantship, studying advanced mathematics, engineering mechanics, technical French, German; desires university teaching position in strength of materials, structural design or structures. Located U.S.A. File No. 5726-W.

MECHANICAL ENGINEER, P.Eng., M.E.-I.C. Long experience in design of heavy machinery, fabricated products, pressure vessels, would like position of engineering or administrative responsibility involving liaison work, use of mathematics. Likes travelling. Preferred location Southern Ontario. Located Central Canada. File No. 5727-W.

CIVIL ENGINEER, Jr.E.I.C., P.Eng., (Ont.) age 39, Veteran. Several years experience in responsible positions in the construction industry. Four years experience with consulting engineers as resident engineer and as design co-ordinator. Seeks permanent position with progressive and growing firm, preferably engineering consultants or general contractors. Available on reasonable notice. Location preferred Ontario or Western Canada. Located Central Canada. File No. 5728-W.

AGRICULTURAL ENGINEER, B.E., S.E.I.C., 1959 graduate of the University of Saskatchewan age, 23, single. Desires agricultural engineering position preferably in Manitoba. Especially interested in structures, irrigation, or hydraulics. Available on reasonable notice to present employer. Located Prairie Province. File No. 5729-W.

MECHANICAL ENGINEER, M.E.I.C., P.Eng., (Ont.) presently Executive Director of Technical Association overseas wishes similar promotional work in Canada. Experienced in technical sales and practical maintenance and construction work. Available on short notice. Located Prairie Province. File No. 5730-W.

THE ENGINEERING INSTITUTE OF CANADA

This service is operated for the benefit of members of the Engineering Institute of Canada and for organizations employing engineers.

SITUATIONS WANTED

Advertisements are inserted free of charge for members of all classes. Maximum length is 60 words, and repeat insertions must be separately requested in writing for each desired appearance.

SITUATIONS VACANT

Rate: Six dollars per column-half-inch per insertion.

Replies to advertisements should be addressed to the file number, Employment Service, 2050 Mansfield Street. Montreal. Interviews with the Employment Service may be arranged by calling VI 2-5078 at the above address.

ures and non-destructive testing. If interested write giving particulars of qualifications: Supervisor, Staff Department, The Consolidated Mining and Smelting Company of Canada Limited, Trail, B.C. File No. 6838-V.

TWO GRADUATE ENGINEERS, Electrical or mechanical for application sales work in electrical machinery. Good opportunity with expanding company in Southwestern Ontario. Reply in full confidence giving all necessary personal data. File No. 6874-V.

MANUFACTURER OF SCIENTIFIC lighting equipment requires two sales representatives for Ontario and Quebec Territories. Applicants should be graduate engineers or the equivalent in experience and possess a high degree of sales aptitude. Salary, commission, expenses and company paid pension. All replies held in strictest confidence. File No. 6890-V.

MECHANICAL AND ELECTRICAL ENGINEERS for design of services in commercial and institutional buildings. Excellent salary and full Associate for right man in three years. Preferably someone between 25 and 40 years of age with 3 to 5 years applicable experience. Consulting Office. Ottawa, File No. 6899-V.

UNIVERSITY OF QUEENSLAND, AUSTRALIA. Applications are invited for the position of SENIOR LECTURER IN INDUSTRIAL ENGINEERING: Salary £A2160/£A2510 p.a. Applicants should have an Honours Degree or higher Degree of a recognized university, together with industrial experience in both the technical and administrative fields. The applicant will be required to assist in the research and teaching work in Industrial Engineering at both undergraduate and post-graduate level. Further particulars may be obtained from the Registrar, University of Queensland, Brisbane, Australia, with whom applications close on 30th January, 1960. File No. 6910-V.

MECHANICAL or CIVIL ENGINEER required for sales organization. Preferably bilingual, experience in sewage disposal or water supply an asset. Some out-of-town travel will be required. File No. 6913-V.

TECHNICAL SALES & SERVICE ENGINEER. Recent graduate to manage sales territory. Montreal area marketing petroleum products to industry. File No. 6914-V.

INDUSTRIAL ENGINEER. Well known and long established Canadian organization with offices from coast to coast, seeks a capable and imaginative industrial engineer for a career position on its Montreal consulting staff. Close association with industrial engineers and other qualified professional consultants will provide the successful candidate with exceptionally interesting experience in working on a wide variety of industrial problems. Preference given to graduate engineers aged 25/30 having a minimum of three years industrial experience in work measurement and related areas of industrial engineering. Attractive compensation range. Applications should provide full particulars and will be held in strict confidence. File No. 6915-V.

CHIEF ENGINEER — to supervise engineering activities and serve as staff engineer of multi-plant operation in Eastern Canada. In order to carry out expansion plans, executive must be familiar with steel plant design and construction, as well as equipment. All replies will be held in confidence by consulting firm. Please send resume to File No. 6918-V.

SALES ENGINEER — Excellent opportunity for aggressive graduate. Mechanical or Chemical engineer, 25-35 years of age who is interested in selling engineered equipment to Pulp & Paper Industry. Some experience in Pulp & Paper Industry desirable. Reply in confidence to File No. 6921-V.

SALES ENGINEERS, two recent graduates, Mechanical or Electrical required by progressive manufacturer of ventilating, air conditioning and related engineered products. Some experience preferred, but not essential. Following completion of Company training course successful candidates will be assigned to Hamilton and Montreal Branch Sales Offices. Wide range of employee benefits and attractive starting salary. Send complete resume and salary requirements. File No. 6923-V.

PRODUCT DEVELOPMENT ENGINEER. Are you the man we are looking for? Age 25-35 years. Education — Graduate of a recognized university in engineering. Experience — 4 to 7 years' professional experience in design, project or development engineering. Position—Engineer in charge of product development function. The successful applicant will be expected to work independently with his technical group in the design, construction of prototypes, testing and preparation of engineering specifications and data, within policy guidance. Our fields of activity include vulcanizing and tire service equipment, and finned tube heat transfer equipment. This is a key position in a small company with excellent growth potential. The location is London, Ontario. Please apply in confidence to: Mr. F. S. Brown, Canada Vulcanizer and Equipment Company Limited, P.O. Box 7, London, Ontario. File No. 6924-V.

OBITUARIES

(Continued from page 94)

katoon, Vancouver, Toronto and Montreal as well as numerous other buildings in the Port Arthur area, was under his jurisdiction.

An active member of the Institute, Mr. Olsson was chairman of the Lakehead Branch in 1949.

Lieutenant Colonel Harold Lyndridge Trotter, M.E.I.C., a partner in the firm of Trotter & Cate (Montreal) for many years, died on December 12, 1959 at the age of 77.

Colonel Trotter earned his degree in military and civil engineering from the Royal Miltary College in Kingston. Prior to World War I he practised engineering with the firm of Ross & Holgate. During the war he served as a lieutenant with the Canadian Royal Engineers (now the Royal Canadian Engineers) and was awarded the DSO.

Upon his return to Canada, Colonel Trotter went into partnership with Carol Cate, forming the engineering firm Trotter & Cate, specialists in hydraulic engineering.

During World War II Colonel Trotter was district military engineer in Halifax, Montreal, and Ottawa. He retired from business five years ago.

The death is announced of Ernest Owen Way, M.E.I.C., a member of the Institute for forty years.

Mr. Way was one of the three Members who became Companions of the Imperial Service Order (I.S.O.) in the Dominion Day Honours of 1946. Six years later the Institute made him a Life Member.

NEWS OF THE BRANCHES

(Continued from page 92)

St. Maurice

William B. Scott, JR.E.I.C.,
Correspondent

On December 8 Dr. David Bate of Atomic Energy of Canada Limited addressed the branch on "Plans for CANDU Nuclear Power Station" which will be constructed shortly on Douglas Point, Lake Huron, near Kincardine, Ontario. As senior design coordinating engineer on this project, Dr. Bates discussed factors affecting site selection, general plant layout, building and equipment design, operating procedures and safety precautions necessary with the use of radioactive materials.

Toronto

D. R. Abbey, M.E.I.C.,
Correspondent

E. B. Griffith, general manager of the Toronto Harbour Commission, outlined the events of the first year of seaway operation at the November 26 meeting. He explained that berthing space is still limited for deep sea ships but that planning is in progress for additional space. He predicted that the Welland Canal would be sufficient for several years to come upon completion of the present improvements.

The October 29 symposium on engineering ethics, moderated by Professor C. A. Morrison, head of the department of civil engineering at the University of Toronto, proved very interesting and informative.

● LIBRARY NOTES

(Continued from page 99)

Pollution", and provides a chemical background for analytical methods used in river pollution. Topics discussed are physical and chemical methods; dissolved oxygen and oxygen demand tests; combined nitrogen; sulphur compounds; alkalinity, acidity, free carbon dioxide, free chlorine, chloride, fluoride; metallic contaminants; various carbon compounds. (Louis Klein. Toronto, Butterworth, 1959. 206p., $6.00.)

*MATHEMATICS APPLIED TO ELECTRICAL ENGINEERING, 2ND. ED.

A comprehensive survey of the mathematics used in electrical engineering. In this edition the two chapters on operational calculus and Fourier Analysis have been completely rewritten and a new chapter on functions of a complex variable has been added. Other new or rewritten sections discuss analogs, eddy current methods of non-destructive testing, and modulation, as well as material on the use of analog computers to solve differential equations. (A. G. Warren. London, Chapman and Hall, New York, Plenum, 1958. 464p., $11.50.)

*FEEDBACK CONTROL SYSTEMS

A synthesis of the field of servomechanisms that combines in a single volume a description of the overall theory, both linear and nonlinear, and of the components used. The subject matter included falls into two categories, the first constituting a text-book on the basic theory of servomechanisms, and the second dealing with additional data on particular and more advanced methods. Special topics discussed are structural stability, transient response of servo with any nonlinear component, stability of nonlinear systems on the verge of instability, forced oscillations of nonlinear servos, Liapunov's direct method, and describing function with statistical input. (J.-G. Gille and others. Toronto, McGraw-Hill, 1959. 793p., $19.00.)

*INDEX TO THE LITERATURE ON SPECTRO-CHEMICAL ANALYSIS. PART IV, 1951-1955.

The fourth part in this series contains 1892 abstracts. They are largely quoted from Chemical Abstracts, although there are occasional quotations from other sources. Although efforts have been made to attain completeness, references to papers containing only a few qualitative results have been generally omitted. (Philadelphia, American Society for Testing Materials, 1959. 314p., $6.50. S.t.p. no. 41-D.)

*SYMPOSIUM ON BULK SAMPLING, 1958.

Among the topics discussed are measurement error factors in bulk sampling, the problems faced in sampling a particular class of bulk material, and the sampling of coal and similar materials.

(Continued on page 110)

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Northern Electric Company Limited have won the E.I.C. Certificate of Advertising Merit for the second time this year. The winning advertisement appeared in the October issue. It is a 4-page, two-colour, insert, black and orange, titled "Northern Electric Serving Canada's Communication and Power Systems". The insert covers a variety of services and products made available to engineers through the company and lists some of the firms Northern Electric represents. The advertisement occupies pages 33, 34, 35 & 36.

Mr. E. H. Woodley is the Advertising Manager of Northern Electric Company Limited and the Montreal office of Foster Advertising Limited, (Account Executive Frank Thompson) placed the business with us.

The selection, as usual, was made by 50 readers of the *The Engineering Journal* who were asked to evaluate the advertisements in the issue from the viewpoints of ACCURACY – INFORMATION and ATTRACTION. The advertisement was repeated in the November issue.

Front *Back*

Centre Spread

NORTHERN ELECTRIC COMPANY LIMITED WINNING INSERT

The above illustration is a reduction, to a small scale, of the 4-page, 2-colour advertisement which fifty readers selected, from the viewpoints of ACCURACY – INFORMATION and ATTRACTION as the "best" in the October issue. The original advertisement, on pages 33, 34, 35 & 36 of the issue was printed in black and orange on heavy white stock.

the world is 3" in diameter

Six Continents lie within the dial of your telephone. By raising your finger you can call any of them. This phenomenon has been created by communications engineers—those men who develop this equipment that shrinks the earth and by those who manufacture and install it. Continuing research is constantly being carried on in the field of communications. Northern Electric designs, manufactures and installs a large proportion of Canada's telephone communication systems and equipment. The experience gained in this field is being utilized in the challenging sphere of Canada's Defence Communications. Northern's experience is all-embracing and includes the manufacture of electrical wires and cables for communications and power transmission. At Northern Electric, product research and development never stops and advances are continually being made.

MADE IN CANADA

Northern Electric

COMPANY LIMITED

SERVES YOU BEST

Business and Industrial Briefs

Appointments and Transfers

Boyles Bros. Drilling Company Limited announces the appointment of Mr. J. D. Campbell to the position of vice-president and general manager of the firm's head office in Vancouver, to meet expansion in both the contract drilling and manufacturing divisions of the business.

James Howden and Company of Canada Limited announces the appointment of E. A. Burgess as eastern area manager. An expanding sales and service program will be directed from the firm's Montreal Office, 1255 University Street.

Research Development and Surveys Associates, Toronto, announces the appointment of Charles Newbury, B.Sc., as senior associate in charge of the newly-formed combustion and pollution division.

Dresser Manufacturing Company, Ltd., Toronto, announces the appointment of J. G. Cushing as manager of operations with headquarters at 21 Coronet Road, Toronto 18.

Watson Jack-Hopkins Limited, suppliers of construction, mining railway and forest fire fighting equipment has appointed R. W. Chorlton as general manager and D. J. Brule as Quebec regional manager.

United Steel Corporation Limited has announced that L. F. Harrison will take charge of the operation of the Standard Steel Construction Company, a division of the corporation.

Canada Wire and Cable Company Limited, Toronto, announces the appointment of J. A. McCrodan as a senior sales representative and that of H. E. Horrocks as sales representative, northern district. Mr. Horrocks will be located in Kirkland Lake, Ontario.

Canadian Liquid Air Company announces the appointment of D. F. McLeod as manager of the purchasing and stores department.

Noranda Copper and Brass Limited has recently appointed M. A. Vachon to the position of chief sales metallurgist.

Hewitt Equipment Company Limited has appointed A. Blouin regional sales manager for Eastern Quebec. He will direct the activities of his region from Quebec City.

General Motors Diesel Limited, London, Ontario, has announced two appointments to the Mobile Training Unit to be taken across Canada. They are P. Marani, supervisor of mobile training and J. Lantagne, instructor in the training activity.

The Hydro-Electric Power Commission of Ontario has announced the appointment of J. M. Hambley as general manager. He succeeds A. W. Manby.

Herbert Morris Crane & Hoist Company, Limited, Niagara Falls, Ontario has appointed R. G. Bonneau as manager of the Company's Montreal Branch at 55 Decarie Boulevard, St. Laurent.

Vickers-Sperry of Canada Limited has appointed B. C. French as district sales manager at Toronto.

Du Pont of Canada Limited has appointed E. T. Challacombe as a technical sales representative for elastomers, which include neoprene newer synthetic rubbers and the basic ingredients of the new urethane materials.

R-O-R Associates Limited, electronics engineers, 3333 Cavendish Blvd., Montreal, announces the appointment of W. W. Hastings to their sales engineering staff.

Hewitt Equipment Limited announces the appointment of J. C. Ackle as regional sales manager for part of Montreal and North-Western Quebec and R. Moreault as regional sales manager for part of Montreal, South Shore and Eastern Townships.

Barber-Greene Canada Ltd. has announced the appointment of F. G. LeDez as manager of its Technical Services Division.

Canada Iron Foundries, Limited has appointed A. G. McNichol manager of Industrial Engineering. Mr. McNichol will make his headquarters in Toronto.

Canadian Industries Limitel has appointed Dr. S. S. Grimley as research manager. He succeeds Dr. I. R. McHaffie whose retirement was recently announced.

Spartan Air Services Limited announces that arrangements have been made with The Bristol Aeroplane Company of Canada Limited whereby V. V. R. Symonds is being released by Bristol to take over as general manager of Spartan.

Business News

Chemesco Limited of Hamilton, Ontario, has designed and built a butane and olefin liquid drier which is being shipped to a western refinery for removal of water, both free and soluble, from butane and olefin foods to an alkylation unit.

Air Reduction Canada Limited has placed on the market two new automatic units for use with Airco's Heliweld welding process. The units are specifically designed for long-run production Heliwelding applications on all ferrous and non-ferrous metals where good weld appearance is necessary or where stringent specifications must be met. For further information contact the company at 905 Hodge Street, Montreal.

Vickers Incorporated recently announced a new deceleration valve for hydraulically actuated machinery. For further information contact Gray & Kilgore, Inc., 18845 West McNichols Road, Detroit 19, Mich.

Metalbestos Manufacturing Company, Brockeville, Ont. has introduced a new chimney of double-wall steel construction designed for every fuel. The chimneys are available in 18-inch and 30-inch lengths.

Toronto Iron Works Limited announces that they have entered into an agreement with British Boiler Accessories Limited of London, England for the manufacture and sale in Canada of British Boiler Accessories Limited products, including B.B.A. steam accumulators and B.B.A. "Helitube" heat exchangers. The B.B.A. accumulator, it is claimed, saves overdriving boilers, decreases fuel and production losses due to steam pressure failure; avoids offensive smoke emission and reduces costs of operation and maintenance of boilers, stokers and burners.

International Business Machines officially opened their 704 electronic computer centre recently in Toronto. Actually, the 704 computer is a series of separate machines packed with 25 miles of wire, more than 4,000 electronic tubes and 13,000 germanium diodes. The machines are linked by the central brain which draws power and information from them and directs the work. Initial cost of the machine is around $1,500,000, but it can be rented for about $35,000 a month.

● LIBRARY NOTES

(Continued from page 104)

(Philadelphia, American Society for testing Materials, 1959. 60p., $2.25. S.t.p. no. 242.)

*SYMPOSIUM ON BULK QUANTITY MEASUREMENT

Papers discussing the use of bulk measurement devices in the petroleum industry. These include hand gage, automatic tank gages, temperature equipment, and positive displacement meters. (Philadelphia, American Society for Testing Materials, 1959. 50p., $2.25. S.t.p. no. 249.)

*SYMPOSIUM ON INSTRUMENTATION IN ATMOSPHERIC ANALYSIS

It has been recognized that continuous analysis and recording of pollutants is necessary for an adequate appraisal of the hazards of pollutants and the effectiveness of any remedial measures taken. With this in mind, the papers included deal with the development of instrumentation to analyse the atmosphere for many compounds and classes of compounds. (Philadelphia, American Society for Testing Materials, 1959. 57p., $2.25. S.t.p. no. 250.)

*FRAMES AND ARCHES

Presents a solution to the analysis of frames or arches of constant or variable cross-section which is based on the classical method and is presented in a convenient, practical form. Time required for frame analysis is considerably reduced. Over 400 condensed solutions for twenty principal types of statically indeterminate frames and arches are given, each solution applying to a particular structure anl load. The solutions allow almost limitless variation in members' shape or cross-section, and can be used in steel, concrete, and wood design. Also included are comprehensive tables and charts to facilitate the analysis of haunched frames and arches. A volume in the Engineering Societies Monographs Series. (Valerian Leontovich. Toronto, McGraw-Hill, 1959. 472p., $23.00.)

*NON-DESTRUCTIVE TESTING

A broad survey of the field of non-destructive testing is made in this volume which discusses such aspects as the production and properties of x-rays, gamma rays, radiological examination, ultrasonic vibrations and testing, surface flaw detection with and without magnetic particles, sorting of mixed materials, and miscellaneous methods of non-destructive testing. In addition there is a discussion of diffraction, safety precautions in radiological laboratories, and the interpretation and presentation of test results. (J. F. Hinsley. London, Macdonald and Evans, 1959. 495p., 75/—.)

*ELECTRICAL SAFETY

Although particularly related to British practice as exemplified in the Factory Acts, there is a considerable amount of information in this volume which is general in nature. Topics discussed include physical aspects of electricity; adequacy and maintenance; cables and lines; automatic protection; switchboards; inflammable surroundings; static electrification in relation to fire and explosion risks. (H. W. Swann. London, Macdonald, 1959. 292p., £2.)

*HELICOPTER DYNAMICS AND AERODYNAMICS

A comprehensive treatment of helicopter theory from the viewpoint of the practicing aerodynamicist and project designer. Aspects discussed are induced aerodynamics, rotor dynamics, dynamics of rotors with hinge constraint, flapping stability and blade movements in gusts, stability and control, rotor vibration, ground resonance and vibration due to rotor resonance, control loads and vibration, blade flutter and rotor weaving, and blade flexing and resonance. A feature of the volume is the recent information on the cantilever, stiff-hinged, high flapping pin offset and other advanced forms of rotor. (P. R. Payne. Toronto, Pitman, 1959. 442p., $17.00.)

*ELEMENTS OF REINFORCED CONCRETE

Featuring an approach combining theory and practical application, methods for both design and detailing are presented. Among the topics covered by the author are flexural stresses in timber, plain-concrete, and reinforced-concrete beams; bond, shear, and diagonal tension; anchorage, embedment, and anchor bolts; reinforced concrete colmuns; retaining walls; foundation design for a steel-framed building; and detailing and drafting of reinforced concrete structures. (S. S. Stern. Englewood Cliffs, N. J., Prentice-Hall, 1959. 444p., $10.60.)

*LINGUISTIC AND ENGINEERING STUDIES IN THE AUTOMATIC TRANSLATION OF SCIENTIFIC RUSSIAN INTO ENGLISH

A report on research done in the field of automatic language translation of scientific Russian into English. An extensive linguistic study of Russian literature was made in about forty scientific fields and resulted in the development of an operational lexicon of about 14,000 semantic units. This lexicon was prepared for use in a photoscopic memory device and translation system developed by the International Telemeter Corporation. Part one is concerned with the linguistic analysis of the problem while part two is concerned with the engineering analysis. (Seattle, Univ. of Washington Press, 1959. Various pagings, $10.00.)

*ADVANCED STRUCTURAL ANALYSIS

A comprehensive analysis of structural theory and its applications. A discussion of the various methods for determining deflections and for solving statically indeterminate structures is first presented, and then followed by advanced topics of current interest such as the theory of arches with reference to the deflection theory, numerical and approximate methods of analysis, torsion analysis, limit design, and temperature analysis. Special chapters deal with the basic theory and design methods of shell structures and with the use of electronic computers to solve structural problems. Throughout the book, an attempt is made to present the basic theory as completely as possible, and then to show the actual engineering applications of the theory. (S. F. Borg and J. J. Gennaro. Toronto, Van Nostrand, 1959. 368p., $8.00.)

*CONTROL ENGINEERING

Modern automatic control theory is covered at an intermediate level. Following a discussion of time response, including a development of Laplace transformations, the characteristics of a large number of control-system components are described, and design in the complex domain covered. The use of frequency-response techniques, a complete treatment of a-c carrier systems, and the analysis of systems with time lag are then presented, and followed by sampled-data systems and the statistical analysis of linear control systems. Concluding sections deal with non-linear control theory and the use of describing functions and the phase plane. (G. J. Murphy. Toronto, Van Nostrand, 1959. 385 p., $8.00.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aircraft

Organization of a large computation in aircraft stress analysis, by A. L. M. Grzedzielski. Ottawa, N.R.C., 1959. (Aeronautical Report LR-257.)

Metods of measurement of aircraft dynamic stability derivatives, by K. Orlik-Ruckemann. Ottawa, N.R.C., 1959. (Aeronautical Report LR-254.)

Bridges

Deflections of an abutment wingwall considered as a thin trapezoidal plate, by H. J. Weiss. Ames, Iowa, Iowa Engineering Experiment Station, 1959. (Bulletin No. 185.) 50c.

Moment analysis for bridge abutment wingwalls of variable thickness, by C. L. Hulsbos and Ti-ta Lee. Ames, Iowa, Iowa Engineering Experiment Station, 1959. (Bulletin No. 184.) 75c.

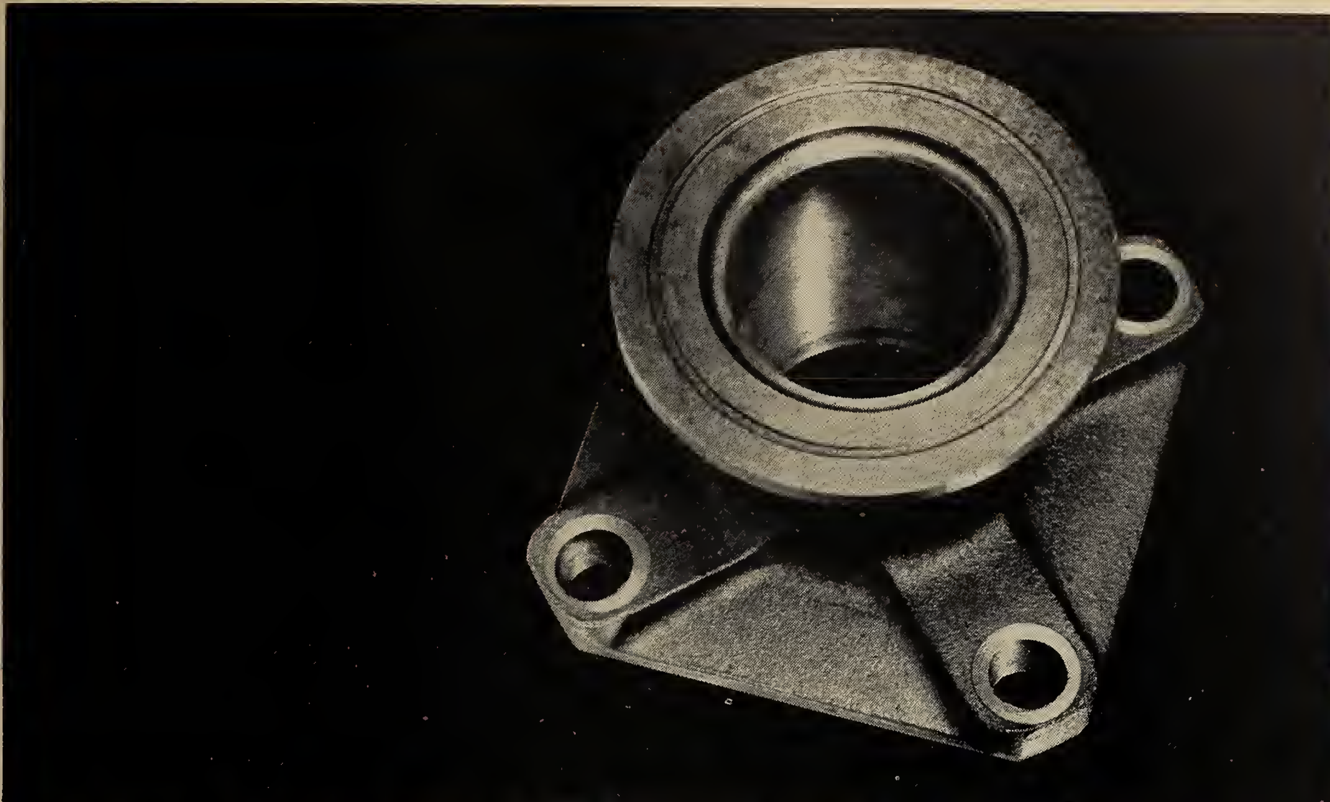
Canada. Iron and steel industry.

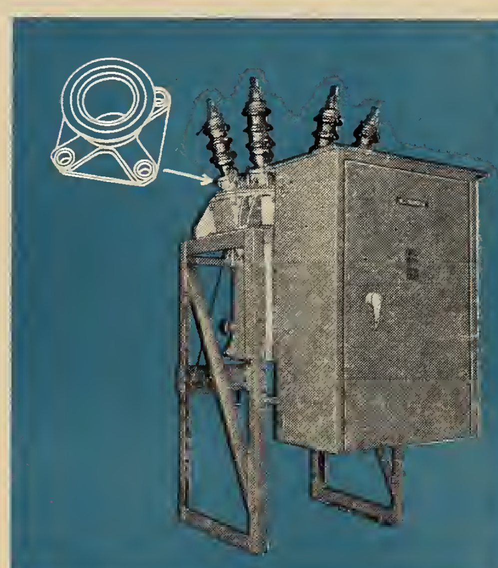
Survey of the Canadian iron ore industry during 1958, by T. H. Janes and R. B. Elver. Ottawa, Dept. of Mines and Technical Surveys, Mineral Resources Division, 1959. (Mineral Information Bulletin MR 31). 50c.

Canada. Zinc and alloys.

Survey of the primary zinc industry in Canada in 1958, by D. B. Fraser. Ottawa, Dept. of Mines and Technical Surveys, Mineral Resources Division, 1959. (Mineral Information Bulletin MR 32.) 50c.

(Continued on page 112)





● LIBRARY NOTES

(Continued from page 110)

Electrical engineering

Insulation for small transformers, by J. H. Mason and C. G. Garton. Leatherhead, Electrical Research Association, 1959. 37/6.

Engineering manpower.

Engineering and scientific manpower resources in Canada: their earnings, employment and education, 1957. Ottawa, Dept. of Economics and research branch, 1959. (Professional manpower bulletin no. 7) 25c.

Engineering research

Pioneering in industrial research; the story of the General Electric Research Laboratory, by K. Birr. Wash., Public Affairs Press, 1957. $4.50

Geology

Effect of elastic properties of rocks on civil engineering design, by W. R. Judd. U.S., Dept. if the Interior, Bureau of Reclamation, 1958.
The importance of geological information as a factor in tunnel lining design, by W. T. Moody. U.S., Dept. of Interior, Bureau of Reclamation, 1958.
Rock mechanics in the investigation and construction of T.1 underground power station, Snowy Mountains, Australia, by D. G. Moye. U.S., Dept. of Interior, Bureau of Reclamation, 1958.

Machine tools

The numerical control of machine tools, by R. C. Brewer. 2d ed. London, Engineers' Digest, 1959. Reprint. (Engineers' Digest Survey No. 5.)

Ship propulsion. Nuclear

Considerations on the disposal of radioactive waste from nuclear-powered ships into the marine environment. Wash., National Academy of Sciences—N.R.C., 1959. (Publication 658.).

Structural engineering

Betrachtungen zur Frage von Stahlbauvorschriften, by C. F. Kollbrunner and S. Milosavljevie. Zürich, Verlag Leemann, 1958.
Knickdiagramme für Stäbe mit sprungweise veränderlichem Trägheitsmoment, by C. F. Kollbrunner and others. Zürich, Verlag Leemann, 1959.

Unions

Unions in America; a British view, by B. C. Roberts. Princeton, Princeton University, Industrial Relations Section, 1959. $2.00.

Wind tunnels

A small wind tunnel for investigating the characteristics of a wing in a finite jet including results of a model with a suction flap, by D. J. Marsden. Ottawa, N.R.C., 1959. (Aeronautical report LR-255.)

STANDARDS RECEIVED

Canadian standards. Canadian Standards Association, 235 Montreal Rd., Ottawa, Ont.

A14.1-1959: Specification for concrete poles (not prestressed). 4th ed. $1.00.
B45.1-1959: Specification for vitreous china plumbing fixtures. $2.25.
C81-1959: Specification for indoor oilless power circuit breakers. $1.25.
080-1959: Specification for wood preservation. 2d ed. $1.00.
Z91-1959: Code of practice for window cleaning. 2nd ed. $1.25.
A23.3-1959: Code of recommended practice for reinforced concrete design. $2.
C22.2 No. 121-1959: Construction and test of electric heating equipment for medical and dental use. $1.50.
086-1959: Code of recommended practice for engineering design in timber. $1.25

ASME standards. The American Society of Mechanical Engineers, 29 W. 39th St., N.Y. 18, N.Y.

ASME boiler and pressure vessel code, 1959 ed., section 1: Rules for construction of power boilers; Section II: Material specifications; Section IV: Rules for construction of low-pressure heating boilers; Section V: Rules for construction of miniature boilers; Section VII: Suggested rules for care of power boilers; Section VIII: Rules for construction of unfired pressure vessels; Section IX: Qualification standard for welding and brazing procedures, welders, brazers, and welding and brazing operators; 1959 Case interpretations.

ASTA standards. The Association of Short-Circuit Testing Authorities, 36 Kingsway, London W.C.2, Eng.

ASTA No. 20: 1959—Rules governing the short-circuit testing and certification of low and medium voltage electric fuses for use on alternating current circuits. 10/-

CSA standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

C22.2 No. 33-1959: Construction and test of electric cranes and hoists. 2nd ed. $1.00.
C22.2 No. 46-1959: Construction and test of electric air-heaters. 3rd. ed. $1.50

Hoist Manufacturers Association, 1 Thomas Circle, Wash. 5, D.C.

Standard specifications for electric wire rope hoists.

THE ENGINEERING JOURNAL

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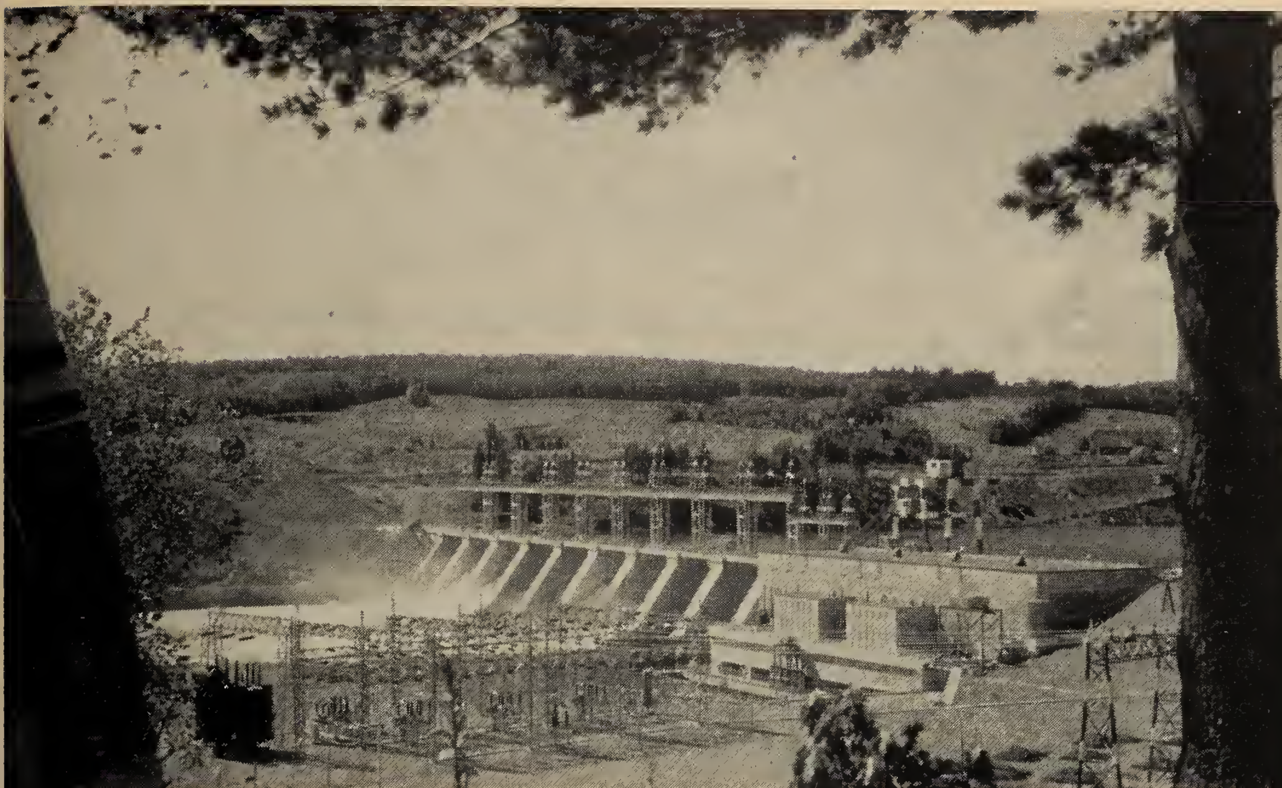
"Electro-Hydraulic Governors at Beechwood Generating Station". G. H. D. Ganong, M.E.I.C., examines starting mechanism in the main valve cabinet. He is accompanied by Cecil Jackson, chief operator at Beechwood.



Shown above is a view of the New Brunswick Electric Power Commission's 72.000 K.W. hydroelectric generating station at Beechwood on the St. John River. Plans are at present under way for the future installation of an additional 36,000 K.W. unit.

ELECTROHYDRAULIC GOVERNORS AT BEECHWOOD GENERATING STATION

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System governing requirements

THE NEW BRUNSWICK Electric Power Commission owns and operates five hydro and four thermal generating stations. The power produced represents about 90% of the provincial requirement and is distributed throughout the province via a 138 kv. and a 69 kv. transmission system.

The Commission's newest and largest hydro development is situated on the Saint John River at Beechwood, whence it gets its name. The Beechwood site was selected from a number of possible choices as the second step in the power development of the Saint John River Basin. Altogether there is a potential of about 434,000 kw. of undeveloped capacity in five sites exclusive of Beechwood.

The load growth today throughout the utility industry is, of course, also being felt by the N.B.E.P.C. Consequently, system planning indicated previous to construction, that this entire potential would probably be required to meet the demand well within the life of the Beechwood station. In addition, it was felt that as the system grew, interconnections would be made with neighbouring utilities. As a matter of fact, the Commission has completed interconnections with The Maine Public Service Co. and The Eastern Maine Cooperative since the completion of the Beechwood station. In addition interconnections have been made with a number of internal power producers. Discussions have taken place with utilities in the Province of Quebec and an interconnection with utilities in Nova Scotia is under construction.

With these considerations in mind, it was anticipated that the Beechwood station would be required to serve initially as a peaking plant and system frequency regulator during periods of low river flow and as a base plant during the higher run-off periods. As the development of further power sites and interconnections progressed, the regulating duty of the plant would shift from a flat frequency requirement to regulation of local or remote tie line power either independent of frequency variations (Flat Tie Line Control) or with frequency biased regulation (Tie Line Bias Control). In other words, a governor was required at Beechwood which could be easily adapted to all these regulating requirements.

The Beechwood development represents approximately 23% of the total generation of the N.B.E.P.C. system with its interconnections. The nature of the system load varies from time to time and from season to season. It is, therefore, desirable to have an accurate and readily available method of altering governor characteristics to match system conditions. The ease of adjustment and the possibility of operating the entire station through a single set of controls is a distinctive feature of the ASEA electro-hydraulic governor. Controls of damping, output and frequency for each machine are available on the bench board. A finger tip motion through an angle of about 270° will change the loading from zero to full capacity. The joint operation feature brings the same finger tip control of the entire station to the operator's desk making station frequency, station output and regulating capacity available for adjustment or alteration as the situation may require without the necessity of moving about the control room.

The above considerations together with the successful application of the of the ASEA governor on the large integrated Swedish system led the designers of the Beechwood station to recommend its use to N.B.E.P.C.

The governor equipment

The governor equipment consists of the following main elements:

The Permanent Magnet Generator;

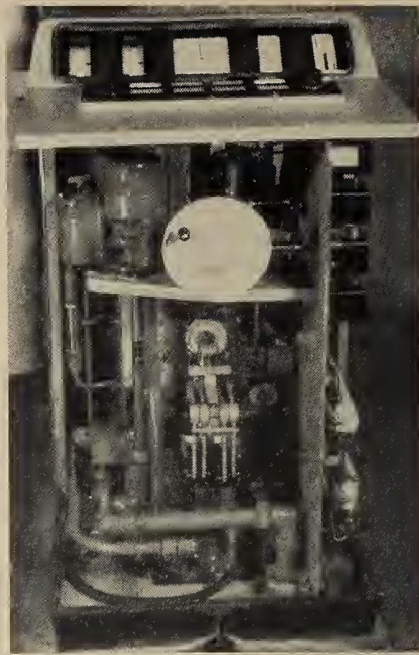
The Regulator Cubicle, containing the electric components, such as the speed sensing circuit, the electric amplifier and various protective relays;

The Actuator cabinet, containing the mechanical parts such as the Transducer, the hydraulic amplifier and associated devices;

The Main Valve Cabinet, controlling the oil admission to the Turbine Servomotors;

The Control switches and selectors to be incorporated in the Control board.

The design and operation of the principal regulating elements are outlined below, followed by sections dealing specially with the control and protective features characteristic of the ASEA Electrohydraulic Governors.



Actuator cabinet with top down showing gauges.

(a) *The Permanent Magnet Generator* — The primary necessity in any governor is, of course, a device capable of supplying the governor proper with an accurate indication of speed. The ASEA governor uses a 60

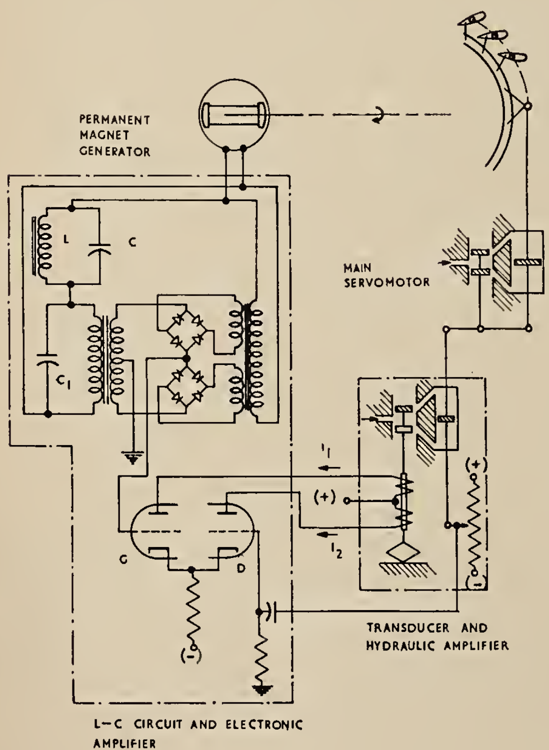
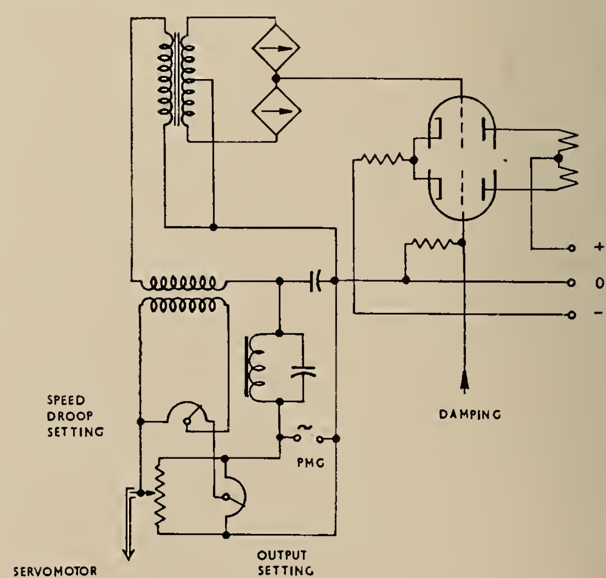


Fig. 1 ***left:*** **Governor schematic**

Fig. 2 ***below:*** **Output and speed droop control circuit**



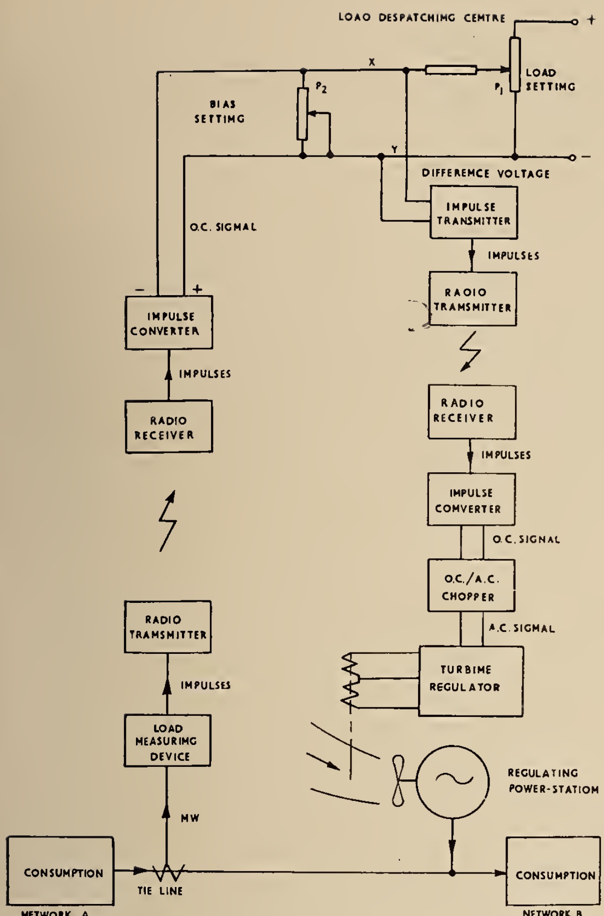


Fig. 3 Schematic for tie line bias control

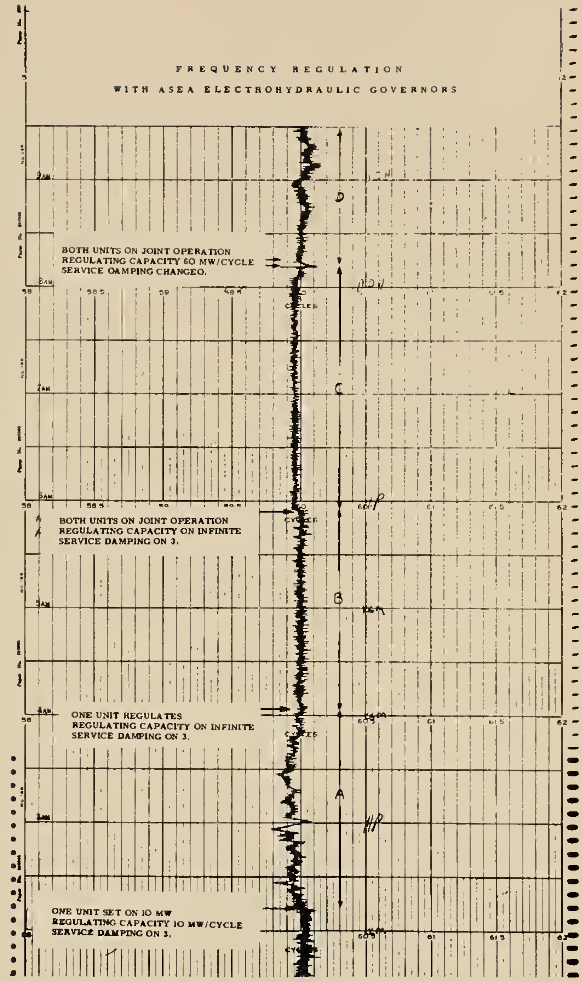


Fig. 4 Frequency chart

cycle threephase Permanent Magnet Generator for this purpose. This PMG is wound with the same number of poles as the main unit. The rotor is of salient pole design and is split to facilitate mounting on the main shaft.

(b) *The Speed Sensing Circuit* — The speed sensing component is a parallel resonant (L—C) circuit tuned at 60 cycles. The PMG frequency is applied to this circuit (see Fig. 1) and as long as it stays at exactly 60 cycles no current will flow through it, the current through the inductance L being equal and opposite to the current through the capacitor C.

If the frequency increases the capacitor current increases and inductance current decreases. The resultant current when passed through another capacitor C_1 produces a voltage drop across C_1 in phase with the PMG voltage. Similarly a drop in frequency produces a voltage drop across capacitor C_1 180° out of phase with the PMG voltage.

In order to make use of this phase angle difference as a governing impulse it must be used to produce a d-c. voltage of suitable polarity. This is achieved by two phase-sensitive rectifiers R. These rectifiers are biased by the PMG voltage and so connected as to act as switches. When the voltage across C_1 is in phase with their bias voltage the rectifying circuit will produce a negative voltage while if the C_1 voltage is 180° out of phase the rectified voltage will be positive. This voltage has thus a polarity depending upon whether the frequency is too low or too high and its amplitude will be proportional to the difference between the actual and the resonant frequency.

(c) *The Electronic Amplifier* — We have shown in the preceding paragraph how a voltage dependent on the frequency deviation is obtained; the next step is to amplify this signal to a suitable power level, introduce the necessary feedback, and use it as a governing signal in the transducer. However, before describing the amplifier it must be pointed out that the frequency signal is only one of the signals that are fed into the amplifier.

A signal dependent upon the output of the unit and the speed droop is superimposed on the frequency signal when the unit is running in separate operation. When in joint operation a signal representing the total output of the power station, a load division signal and the regulating capacity signal (equivalent to the inverse of the station speed droop) are added. Other signals are superimposed to allow the unit to run as a synchronous condenser. Any other variables whether measured locally (e.g. water level) or transmitted through a remote control link (such as a tie line output) can be introduced as regulating signals, the sole condition being that each can be represented by a proportional 60 cycle voltage. These additional control signals are simply introduced into the circuit of the phase-sensitive rectifier by transformers connected in series with the transformer for the frequency signals.

Such control signals can be obtained in a relatively simple way and we will describe the arrangement for the output control. An induction device, fed by the PMG voltage, is built into the actuator cabinet and will produce a voltage dependent on the position of the wicket gates and, therefore, proportional to the output of the unit. The output setting device is a potentiometer fed by the same PMG voltage. The difference between the voltage set on the output setting potentiometer and the voltage from the induction device (representing the output of the unit) is the desired output regulating signal.

To adjust the speed droop, this output regulating signal can be reduced in an adjustable proportion by passing it through another potentiometer before feeding it into the amplifier. If the whole output regulating signal is admitted into the amplifier (maximum speed droop) the governor performance will be very dependent on the output. Reducing the speed droop means adjusting the corresponding potentiometer so that the influence of the output is decreased until, at zero speed droop, no part of the output regulating signal is admitted and the governor becomes dependent upon the frequency only. The same principle is applied to regulation by other variables. In water level regulation the voltage from the output setting potentiometer would be replaced by a voltage proportional to the water level. In tie line regulation a voltage dependent on the power flow of the line would substitute the output setting potentiometer and so on. The additions required to adapt the governor to these other kinds of regulation are always of a very minor nature.

The amplifier proper contains a double triode symmetrically connected as a balanced differential amplifier, (see schematic circuit on Fig. 1). The plate current of the tubes will flow through the two halves of the transducer solenoid and cause it to move in one or the other direction, depending on which current prevails. At rest, i.e. with both grids at zero potential, the plate currents of the two halves of the tube are the same and, since they act in opposite directions on the transducer solenoid, the resultant ampere turns and force will be zero. The cathode resistor is so chosen that the voltage drop across it equals the negative d-c. supply.

When a small voltage signal from the sensing circuit alters the grid potential of triode G, its plate current I_1 will change. The current I_2 in the triode D (its grid still at zero potential) will change in the other direction so as to maintain the sum $I_1 + I_{r2}$ constant; this is because the total cathode current $I_1 + I_2$ is mainly determined by the value of the cathode resistor and the negative d-c. supply. The difference $I_1 - I_2$ will now act upon the transducer solenoid and cause it to move; the hydraulic amplifier and wicket gates will follow.

A d-c. voltage of opposite polarity on the grid of tube D would have had the same result due to the symmetry of the arrangement. If triode G is used to amplify the governing signal, triode D can conveniently be used for feedback or damping.

The damping circuit fulfils, in the electric governor, the same function as the dashpot in a mechanical governor, that is it prevents overshoot and gives a smoother regulation. A d-c. voltage proportional to the movement of the actuator rod (which in the ASEA governor is precisely followed by the wicket gate servomotors) is used to charge a capacitor and fed into the grid of tube D; the electrical connections are such that the current induced in the triode (and transducer solenoid) will counteract the movement that has caused it. In short, a governing impulse through triode G will cause a movement of the actuator rod and gates that through the damping circuit and triode D will work against the original impulse and try to stop the movement before any overshoot appears. The damping circuit is only shown as one capacitor and one resistor on the schematic of Fig. I, but it is actually somewhat more complex. Various selectors are provided to permit choice over a very wide range of the voltage to be fed into grid D and the discharge time of the capacitors of the circuits. By suitably selecting the size of the damping voltage and the length of time during which it is allowed to act on the grid, it is possible to obtain very fast and stable regulation. Further, the damping can be changed at will during on-the-line operation without any disturbance. When running at no-load a considerably higher damping is required than when running in parallel with other machines. The change over to no-load damping is carried out automatically and instantaneously when needed.

The components of the governor described above are purely electric and are housed in the regulator cubicle together with protective relays and other electric devices (such as equipment for spinning reserve operation) that may be connected with the governor. The location of this cubicle can be chosen independently of the location of the other elements of the governor equipment, since the only connections between them are electrical. In Beechwood the governor cubicle is placed beside the voltage regulator equipment.

(d) *The Transducer and the Hydraulic Amplifier* — The hydraulic and mechanical parts of the governor are placed together in the so called actuator cabinet on the generator floor. This contains the transducer, the hydraulic amplifier as well as indicating gauges and facilities for hand control. The actuator cabinet is the link between the purely electric components of the governor and the relay valves which in turn act on the servomotors.

The transducer, as mentioned previously, consists of a small solenoid that can move in a permanent magnetic field and controls a small pilot valve. The whole assembly is machined with the utmost precision and designed for maximum reliability and sensitivity. There are no bearings and the movable parts are positioned by one spring at one end and by oil streams at the other end. This design eliminates both friction and wear. The d-c. current from the electronic amplifier causes the transducer solenoid to move in the magnetic field and displaces the pilot valve from its neutral position. This valve then admits oil to a hydraulic amplifier that finally determines the movement of the actuator rod. This rod is connected to the pilot valve in the main valve cabinet and decides the position of the turbine servomotors. A position indication is obtained from the actuator rod and is used both for damping and as a restoring signal for the output. While the speed of response of the transducer to governing impulses is inherently very high, the operating times of the hydraulic amplifier are adjusted so as to be only slightly smaller than the main servomotor operating times.

The gate limiter is designed as a mechanical device to limit the travel of the actuator rod. When hand operation is desired, the gate limiter is used as a gate setting device.

Another important detail is the actuator lock, a cam and ratchet device that locks the actuator rod and thus puts the governor temporarily out of action.

For operating convenience the actuator cabinet contains the brake controls and various gauges and indicators, i.e.

Speed meter
Governor balance meter
Gate and gate limiter position
Accumulator and actuator oil pressure
Servomotor oil pressure

While the transducer is of ASEA manufacture, the hydraulic amplifier and the rest of the actuator cabinet has been supplied by Messrs. KMW.

(e) *The Main Valve* — The main valve is the final stage of amplification. Governing signals originating at the transducer are amplified in the actuator cabinet and are transmitted to the main valve pilot through the elastic actuator rod. Displacement of the main valve pilot causes oil under pressure to be admitted to the unit servomotors through the main valve. The restoring cable recentres the pilot as soon as the wicket gates have reached the required position.

The main valve cabinet also contains the blade valve. This is operated through a cam follower which follows the wicket gate position.

Maximum efficiency is obtained when the blade gate relation follows the pattern ascertained through Index tests. The relationship alters appreciably with a change in net head, consequently a three dimensional cam is provided to produce the required relationship through a head range from 45 to 65 ft.

At start, however, the relationship set forth by the cam surface does not give the maximum starting torque. A starter device is, therefore, provided to make the turbine start with fully open blades and to bring back the blades to the optimum efficiency position after a few seconds. An additional three-way solenoid insures the correct positioning of the blades while running as spinning reserve.

The start and stop solenoid for the turbine is also located in the main valve cabinet. It acts directly on the pilot valves and is, therefore, completely independent from the governor itself. The main valve cabinet is also of KMW manufacture.

Control Features

Control of the turbine may be exercised manually from either the actuator cabinet located on the generator floor or from the control room where remote indications of speed, gate and gate limiter position are available.

The controls for automatic operation are located on the benchboard or control panel in the control room together with the other voltage regulation and circuit breaker controls of the unit. They are:

Frequency setting knob;
Output setting knob;
Damping switch and selector;
Joint operation switch;
Actuator lock switch.

The unit is started up by opening the gates with the gate limiter (manual control). At about 85% of rated speed the governor will automatically take over and bring the unit to the speed set on the frequency setting knob; the unit can now be synchronized. After closing the line breaker the required output is set on the output setting knob and the damping of the governor can be changed from its no-load value to a suitable service value.

If it is so desired, the entire station may be operated as a single unit from the operator's desk. This feature of the ASEA governor is called "joint operation" and Frequency, Regulating Capacity and Station Output controls are within easy reach on the operator's desk.

In our particular case the load is shared equally between the machines during "joint-operation" since the units are similar. However, a different load division could be arranged if desired. While on "joint-operation" the damping of the two units may be either set to the same value, thus allowing a maximum of regulating capacity for both fringe and sustained load changes or, they may be set so that one unit responds to fringe swings and the other to sustained load changes. However, they will both return to the preset load division within a very short time.

Before being synchronized the transient behaviour of the unit was determined by the no-load damping. (This damping is chosen and set with the aim of obtaining quiet and stable running at no-load and at load rejection). It is, therefore, a considerably higher damping than what would be required when running in parallel with the system. After synchronizing, the link with the system contributes towards damping whatever oscillations may be induced in the units by load or frequency variations and so a considerably lower degree of damping can be used on the governor. The service damping is, therefore, switched in to substitute the no-load damping and its value may be selected from a wide range and changed at will during operation.

On conventional mechanical governors there is one dashpot for the service damping and its characteristics cannot easily be modified. This new flexibility of damping, as afforded by the electrohydraulic governor, has been found very valuable and is extensively used to adapt the performance of the units to the varying requirements of the system.

The actuator lock is another convenient feature of this governor. It is possible to lock the actuator mechanically and thus hold the gates in any position, irrespective of subsequent governor signals. If the system frequency should deviate more than 0.5 cycle from the set value a frequency relay will release the actuator lock automatically and restore the governor control.

The spinning reserve—synchronous condensing feature of the Beechwood development is perhaps unusual and, for that reason, may be of interest. The control circuits are so arranged that turning a switch labelled "Motoring—Generating" places a closing signal on the electric-hydraulic transducer. This results in the wicket gates being closed and held closed as long as the signal is maintained. In addition air is admitted below the head cover depressing the water in the draft tube to a point below the turbine runner. The runner blades go to the fully closed position through the action of a three-way solenoid valve located in the main valve cabinet. All losses are, therefore, reduced to a minimum.

In the event of a system disturbance resulting in a frequency dip below a predetermined minimum, a frequency relay operates placing an opening signal on the transducer and closing the air inlet below the head cover. The wicket gate will then go to full load position unless prevented from doing so due to system frequency correction. The unit is considered spinning reserve even though it is being used for condensing purposes since it will pick up to full load within about six seconds after a frequency dip has been experienced.

Protective features

Since the PMG gives a very reliable and exact indication of the speed of the machine, an electromagnetic relay is used as overspeed switch. This has the advantage that the operation of this relay and connected circuits can be checked at will by applying a suitable voltage without having to raise the speed of the machine. This must be considered as an advantage over mechanical overspeed switches that are practically never tested after installation.

Other speed relays are used for the brake circuit and creep indication. Magneto electric relays with very low power consumption are used for this application; they have a very high accuracy and their setting can be altered over a considerable range. There is no limit to the number of relays that can be installed or added later and their operating values can be chosen and altered at will. Furthermore, these relays can be tested independently from the PMG.

The governor equipment is self-protecting to the greatest possible extent. Relay protections are designed so that a minimum of disturbance will result from a failure of any component part. The protective functions included in the Beechwood equipment are:

(1) Abnormal PMG voltage;
(2) PMG overload;
(3) Amplifier failure;
(4) Governor hunting;
(5) Low oil pressure;
(6) High and low frequency;
(7) Automatic damping change over.

In the event of a regulator fault, such as tube failure or loss of PMG output, the actuator lock is automatically applied through one of the above relays.

If at the same time or subsequently the PMG frequency should become appreciably higher than normal, a signal is applied to the transducer to guide the gates to no-load position.

If, while on system regulating duty, the unit breaker should be tripped due to either line or generator protection, the governor concerned is automatically disconnected from joint operation and the damping is increased to the preset no-load value.

The stop-start solenoid operates directly on the main valve and is located in the main valve cabinet. It is, therefore, independent of the transducer and will act directly on the hydraulic system should it be so required through the operation of any associated unit protection device such as loss of excitation or generator differential protection.

In the electric circuits no fuses are used. All circuits are protected by no-fuse breakers with instantaneous and thermal overcurrent relays. These breakers are provided with an alarm contact to attract the operator's attention immediately upon the failure of one circuit. As mentioned, the governing and the protecting circuits of the PMG are electrically separated. Auxiliary DC is used for the operating and indicating circuits of the governor equipment. While the operating and protective circuits of the governor are dependent upon the auxiliary DC supply, the regulating circuits are fed only by the PMG. A momentary failure of either of these circuits will not affect the output of the power station.

Operating experience

The Beechwood governors have now been in operation approximately a year and a half, and have performed in a very satisfactory way. This refers both to the performance and to the maintenance record.

The primary objective of good frequency regulation has been achieved as illustrated in the frequency chart shown on fig. 4.

On the first section from the bottom (marked A) the frequency is shown with one unit connected to the system and set for a regulating capacity of 10 Mw./cycle. At this value the unit runs practically at a constant output and the governor is made rather insensitive to the frequency variations. The frequency is controlled by other units on the system and the frequency variations are rather noticeable.

On the second part (marked B) of the chart the regulating capacity has been increased to infinite. (This is equivalent to saying that the speed droop is zero). The unit is then on flat frequency control and it can be seen that the frequency variations stay within ±0.05 of a cycle. It should be noted that these variations are the transient variations due to the load changes. The centre line around which the frequency oscillates has a constant value and no deadband can be detected within the accuracy limits of the measuring instruments.

On the third section (marked C) of the chart both units are connected to the system in joint-operation and regulate the frequency with infinite regulating capacity. The band of the transient frequency variation has been narrowed down to about ±0.03 cycles.

In the fourth section (marked D) both units have been kept on the line but the regulating capacity has been reduced from infinity to 60 Mw. per cycle. It is readily seen that the frequency now fluctuates considerably following the load variations.

From the description of the governor design and control characteristics, it is apparent that it differs considerably from the conventional mechanical type. The most salient differences are:

the possibility of setting the output independently of the frequency setting;

the possibility of running the units in joint-operation;

the flexibility attained through having adjustable speed droop of each unit when they are in separate operation and in addition adjustable regulating capacity (the inverse of speed droop) of the whole power station in joint operation;

the possibility of varying the transient behaviour of the units through the damping adjustment.

We wish to point out, however, that although the ASEA electrohydraulic governor offers greater flexibility than conventional governors, the station operators' task has not been made more complex.

The operating staff soon became familiar with the additional features afforded by these governors. The use of these controls is now a matter of routine and it would probably be difficult to satisfy the operators with a governor lacking these novel features.

As far as maintenance is concerned, it can be safely stated that there is none for the electrical part. Wherever possible induction devices have been used instead of potentiometers, in order to eliminate a possible wear problem. The contact wear on relays is quite insignificant, due to the very ample design. For the hydraulic part, the filters are periodically cleaned, but apart from this, no other measures are recommended nor have been required.

Summing up, in the light of the operating and maintenance experience of this first year and a half of operation, it can be said that the ASEA electrohydraulic governors have fulfilled all the expectations and have completely justified the bold decision of the New Brunswick Electric Power Commission in installing this new device.

MOORING DOLPHINS FOR THE HARBOUR OF KITIMAT

A. Bernups, M.E.I.C., *Senior Civil Engineer,*
General Engineering Department, Aluminum Company of Canada, Ltd.

Application of large diameter high tensile, low alloy tubular steel piles made possible the design and construction of flexible type mooring dolphins for Kitimat Harbour. The flexibility of long vertical piles was utilized to absorb the berthing impact energy of large cargo vessels and also to resist the static mooring loads. Unconventional pile handling and driving methods facilitated the execution of work in the harbour with 20 ft. tidal variations. Simplicity of the design and a careful scheduling of all construction phases were two governing requirements.

GROWING ALUMINUM smelter capacity necessitated in 1956 the planning of additional harbour facilities at Kitimat. The first harbour structure built at the early stage of the development was a temporary timber pile wharf which served mainly for plant construction purposes. Subsequently this wharf was used for handling coastal traffic for Kitimat Townsite. A reinforced concrete caisson type wharf was constructed in 1953, providing berthing space for ocean-going cargo vessels up to 30 ft. draft. This structure which is 760 ft. long is known as Terminal Wharf No. 1 and is equipped to handle all inbound shipments of raw material as well as outbound shipments of metal.

Fig. 1. shows the existing and planned possible future harbour development, including the mooring dolphins, installed in 1958.

Requirements

At the end of 1956 the Terminal Wharf already had a berth occupancy figure of 40% and with additional new potlines under construction it was necessary to plan an extension for the berthing of cargo vessels.

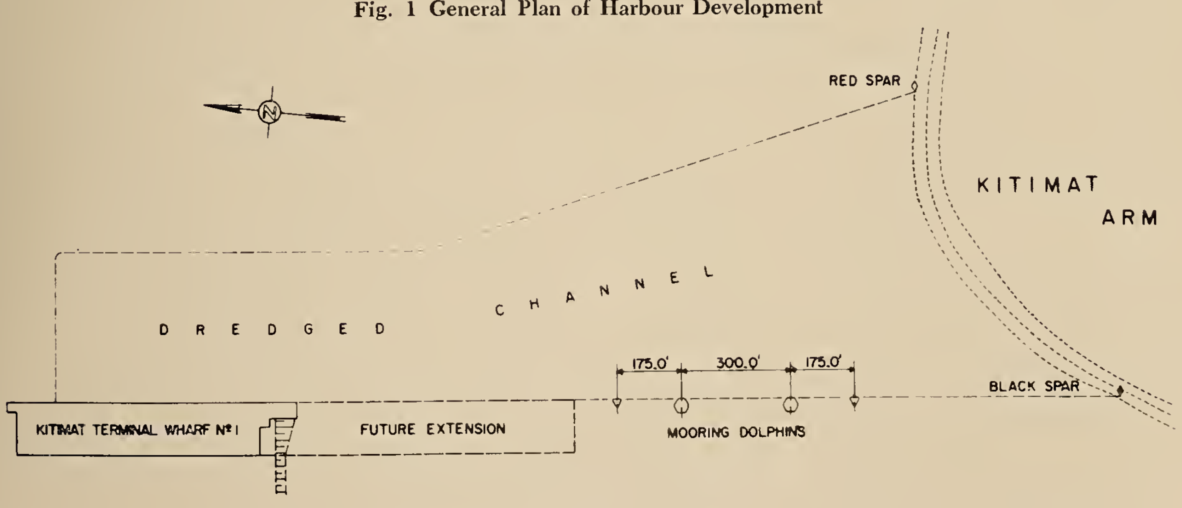
Fig. 1. shows that the original wharf was designed and located so that a future extension southward was possible. However, an expensive wharf extension did not appear economically justified in 1957; therefore, to cope with the immediate future requirements, an installation of mooring dolphins was decided upon. The dolphins had to provide safe mooring for a vessel arriving in the harbour while the wharf was occupied. For any cargo handling operations the vessels had to be moved to the Terminal Wharf as soon as a berth became available.

From consultations with officials of Saguenay Shipping Ltd., who operate most of the ships using Kitimat Harbour facilities, the following requirements were established. Two main dolphins or "strength dolphins" were to be designed to resist impact forces resulting from the berthing of a ship. The same structures were to resist afterwards the pull of the ship's spring and breast lines. Apart from that it was found necessary to install two "end dolphins" to hold the bow and stern mooring lines after the berthing of the ship and to provide some additional resistance along the line of dolphins.

Parallel with the design of the mooring dolphins, the planning of the ultimate harbour development was advanced and the dolphins were located to allow for a future Terminal Wharf extension of 750 ft. As shown in Fig. 1., the dolphins are situated south of the wharf at the entrance to the dredged harbour basin and only some 500 ft. away from the deep water of Kitimat Arm.

The prevailing winds are nearly due north or due south, following the direction of the valley. This factor had already been considered in the original harbour design. The mountain ranges offer some wind protection, particularly from the West; however, wind velocities up to 60 m.p.h.

Fig. 1 General Plan of Harbour Development



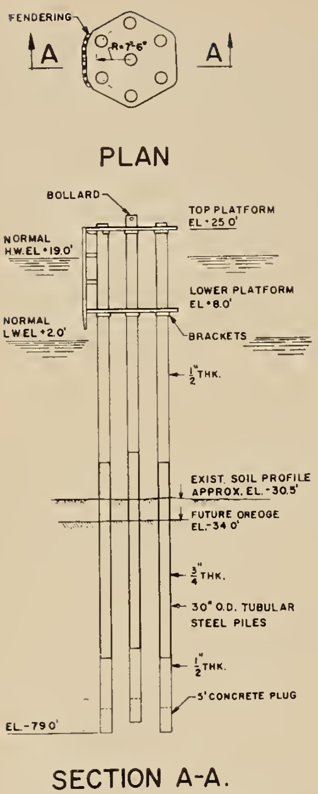


Fig. 2 *above:* Main Dolphin

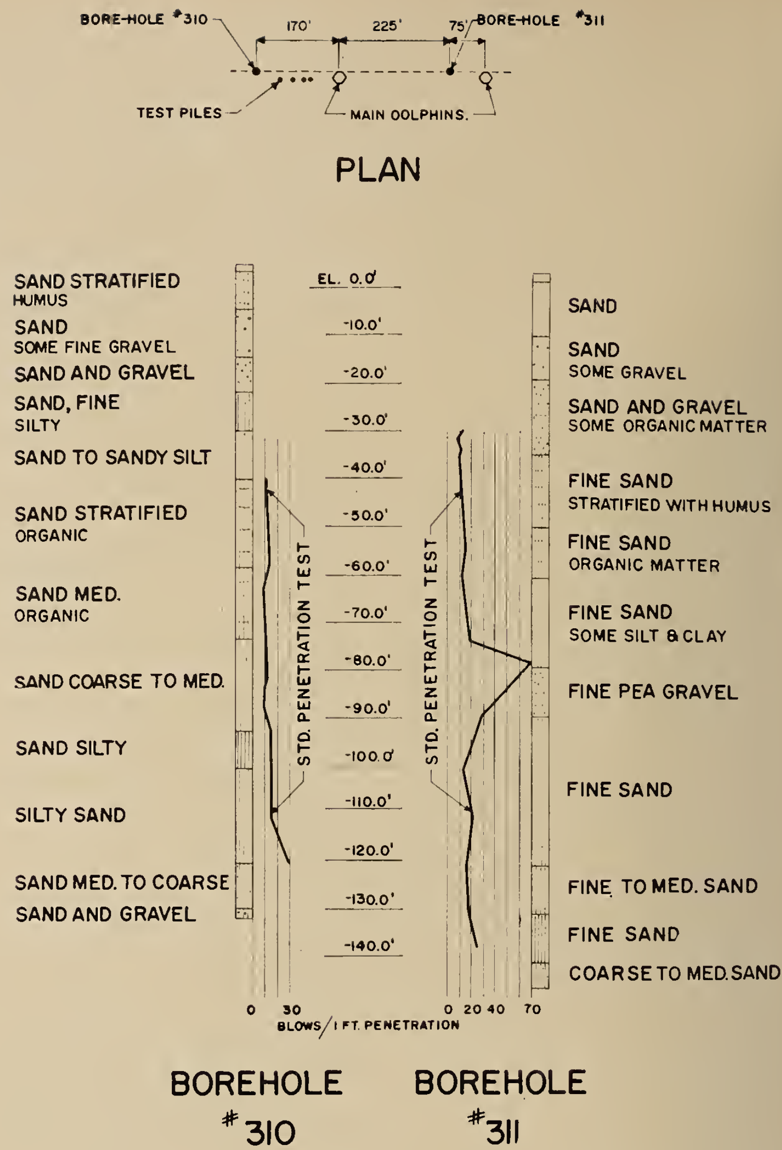


Fig. 3 *right:* Soil Stratigraphy and Penetration Resistance

have been recorded and during several storms velocities up to 80 m.p.h. have been estimated. The effect of such winds had to be considered.

The axis of the installation was selected so that the fendering of the dolphins lines up with the fendering of the wharf. The centre-to-centre distances of the dolphins were chosen to allow for mooring of vessels from 10,000 to 16,000 T.D.Wt.

As the basis for the design the following data were to be used:

Load displacement of ship, representing the moving mass of a 16,000 T.D.Wt. cargo vessel: . . . . 24,000 sh.t.
Maximum angle between ships approach line and line of dolphins . . . . 15°
Maximum approach speed of a vessel normal to the dolphins . . . . 0.5 ft/sec
Wind pressure . . . . 20 lb/sq.ft.

Selection of Dolphin Type

Prior to the selection of mooring dolphins a mooring buoy alternative was investigated. The depth of water at the possible location of a mooring buoy in Kitimat Arm is about 60 fathoms and the bottom consists of silt. Detailed studies showed that the ground anchorage and the methods for laying the ground tackle would be complicated. This alternative also had the disadvantage that extended pilot service would be required while the ships were at the anchorage, some 5,000 ft. away from the wharf. The scheme was abandoned finally.

Several dolphin arrangements and types of pile construction were studied before the final design was adopted.

The construction methods had to be as simple as possible to cope with the extreme tide conditions varying between elevations of +0.58 ft. and +23.08 ft.

Pressure creosoted timber piles were considered first but it was soon realized that the scheme was not very feasible, because of the great number of batter piles required to resist the impact and wind loads. Also a concrete capping would be required to engage the resistance of all dolphin piles. Such concrete work would be very difficult because of the tide conditions.

Steel sheet pile cells 27 ft. in diameter, penetrating the soil for some 40 ft. and gravel filled above the bed elevation, offered reasonable factors of safety but the costs involved were found to be high compared to other choices.

Further studies revealed that flexible vertical steel piles could be used with advantage to absorb impact energy of a vessel, although this flexibility has some disadvantage for resistance to static mooring loads.

The selection of this dolphin type was influenced also by technical articles, describing successful flexible dolphin installations of similar type at the Port of Amsterdam.

As shown in Fig. 2., the final design used long, vertical, tubular steel piles as flexible members to absorb the ships' kinetic energy.

Seven piles were used for each main dolphin and three piles of the same type were used for each of the end dolphins. Two horizontal steel platforms for each dolphin were introduced to provide the tie between the piles. As the platforms are supported loosely on the brackets at the piles, the lateral loads do not cause any appreciable axial pile loads. The tubular piles offer equal resistance to lateral forces from any direction and each pile is acting essentially as a long cantilever. It was proved later that the fabrication and erection of steel platforms was a comparatively easy job, considering the tidal conditions, while the handling and particularly the driving of tubular piles involved some problems.

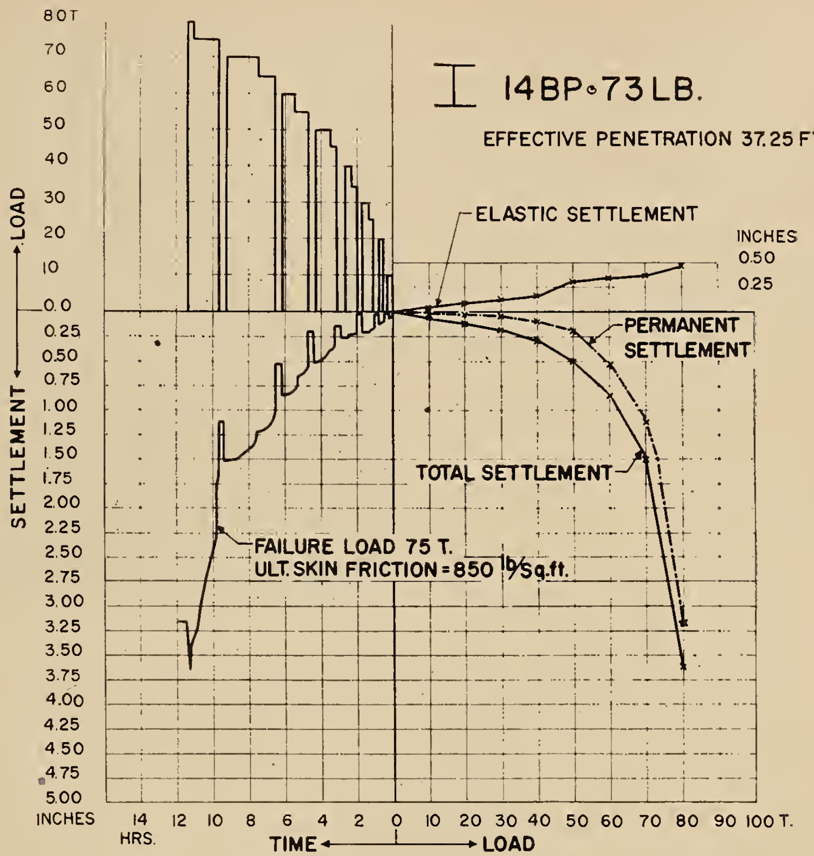


Fig. 4 Pile Loading Test Data

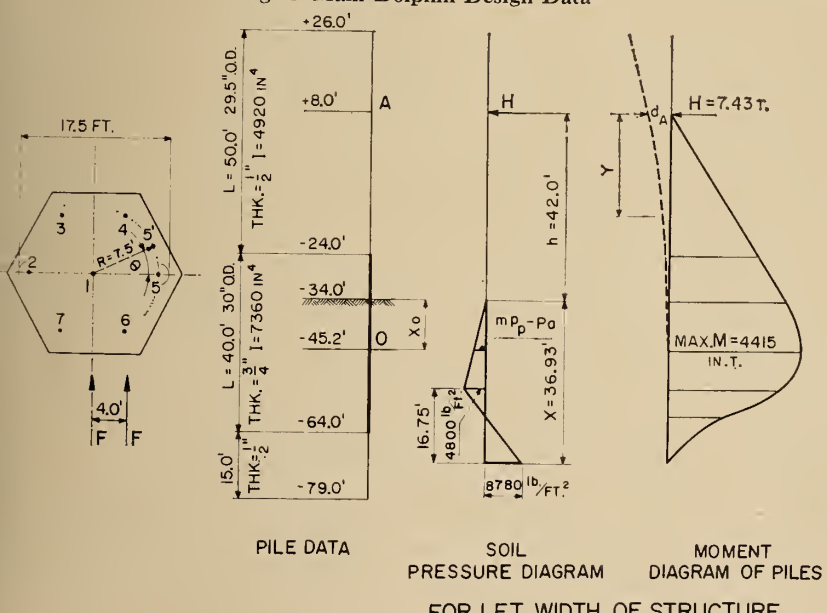
Soil conditions

The topography of the Kitimat area is characterized by high peaks and low valleys. A large delta area with tidal flats has been formed by the Kitimat River which empties into a fjord known as Kitimat Arm. The floor of this valley is at great depth and bedrock beneath the tidal flats is covered by post-glacial sediments, varying in thickness up to a maximum of 450 ft. The deposition of these sediments has been affected by fluctuating coastline and ocean levels.

Extensive soil investigation was carried out in the harbour area in 1952 before the construction of the Terminal Wharf. Altogether twelve borings were made at that time to determine the soil profile, the penetration resistance, and to obtain the necessary soil samples for laboratory testing. The borings covered the area of the initial wharf site as well as the future wharf extension area and the site of the present mooring dolphins. Fig. 3. shows stratigraphy and penetration resistance of soil from the two borings nearest to the site of the dolphins.

The soil below the dredged bottom elevation—31.0 ft. can be classified as complex granular non-cohesive material, consisting mainly of fine silty sand of medium density. Consolidated undrained tests indicated an angle of internal friction varying from 20° to 43°, with an average of 30°. Most of the soil samples had little or no cohesion with a maximum value of 1,000 lbs. per sq. ft. The in-situ dry density of the soils varied between 80 and 95 lbs. per cu. ft., while the water content varied between 30% and 43%.

Fig. 5 Main Dolphin Design Data



Pile loading tests were carried out in the harbour area in 1957, with the main purpose of determining the permissible pile loads for a possible future wharf extension on piles. The tests supplied also some information for the dolphin pile design.

A characteristic time-load-settlement graph for one of the test piles is shown in Fig. 4. Altogether six loading tests were carried out with four piles.

Ultimate loads yielded average skin friction resistances of 750 lb. per sq. ft. for 14 in. H piles and 1,000 lb. per sq. ft. for a 12 in. diameter tubular steel pile with a conical tip, assuming that in both cases the loads were transmitted to the soil entirely by skin friction.

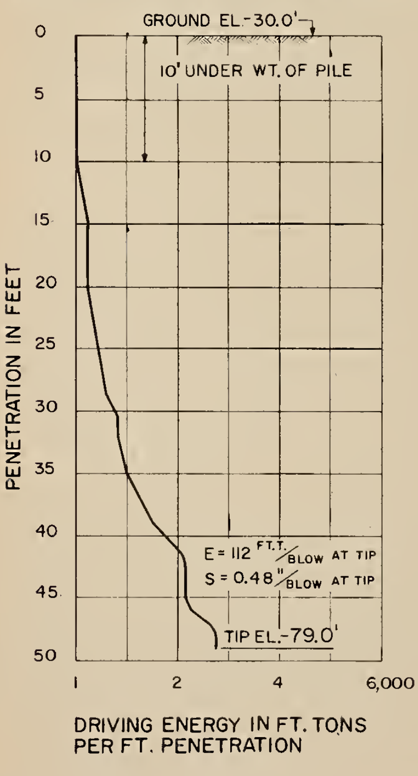
It was apparent that the shape of the pile had some effect on the pile resistance. While the H pile was merely cutting the soil, the cylindrical pile acted as a soil displacing pile. It was further observed that an increase in penetration depth of the piles within the same soil layer did not produce a proportional increase in driving resistance. This leads to the conclusion that the prolonged driving affected the pore pressure of the surrounding soil and reduced the shear resistance of it. On the other hand, piles regained driving resistance after some period of rest and nearly became "frozen". This was evidenced during the redriving of piles and after field splicing of piles.

Apart from supplying information on possible frictional values, the tests gave an indication of the difficulties which could be expected when driving large diameter piles. Suitable equipment had to be chosen to overcome the frictional and end resistances of the piles and the driving methods had to be planned to ensure continuous driving for each pile. Splicing of piles during the driving was ruled out completely because of the danger that they might become "frozen".

Design of Dolphins

The design took into account the future planned dredging of the harbour basin down to El.-34.0 ft.

Fig. 7 Diagram of Pile Driving Energy Used



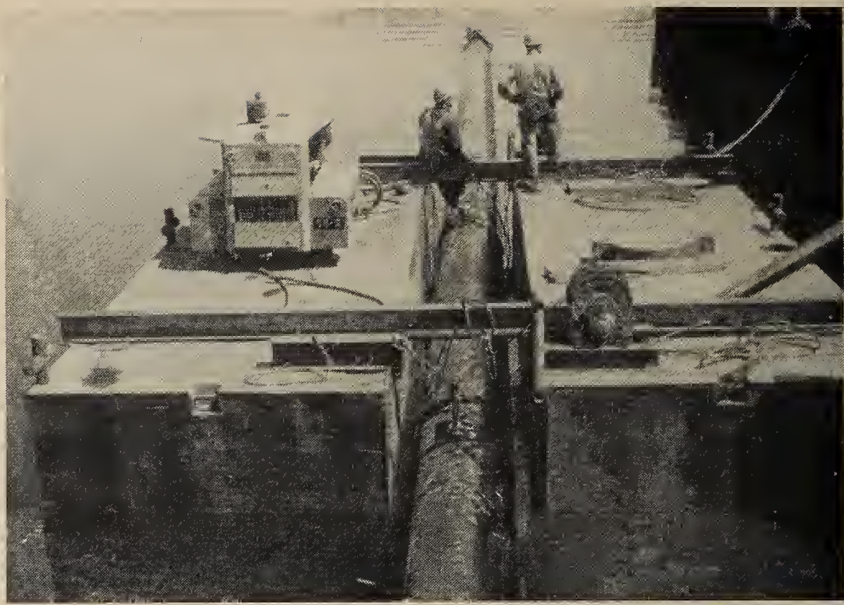


Fig. 6 Floating of Piles to Site

Loaded and unloaded vessels were considered in determination of the wind force on the ship. Further, it was assumed that from the total kinetic energy of the berthing ship only 50% will be absorbed by the two main dolphins, while the rest of the energy will be lost due to the water displacement in a broadside movement towards the dolphins, and due to the loss of energy on first impact.

Two cases of berthing were considered:

(a) Broadside collision of the vessel with the main dolphins, engaging both structures simultaneously. In this case the energy to be absorbed was considered equally distributed to both structures;

(b) Collision with only one of the main dolphins. Because this type of impact is unlikely to occur amidships, a reduction coefficient of 0.5 was used for the moving mass.

Hence, in either case, the energy to be absorbed by one main dolphin was the same. It follows that in case (a) the dolphin absorbs the energy in pure bending, while in case (b) the structure may be also subjected to torsion, caused by a glancing blow.

Comparative design studies revealed that high tensile, low alloy steel piles can be utilized better than medium structural grade steel pipes to resist the cantilever moments for this particular structure. Welded steel pipes of 30 in. diameter, complying with ASTM Specification A-252, Grade 3, were selected, having an ultimate tensile strength of 75,000 psi. and an ultimate yield stress of 45,000 psi. The use of this steel offered considerable saving in pile transport, handling, field welding and driving costs as compared with medium structural grade steel piles.

Considering the nature of the design loads it was decided to use a maximum working stress of 37,500 psi. for cases of pile bending. This means a theoretical factor of safety of 1.2 against yield failure and a factor of safety of 2.0 considering the ultimate strength. Actually the inspection tests during the fabrication of the piles showed that the ultimate stress of the material varied between 78,000 and 89,000 psi. and the yield stress was between 52,000 and 59,000 psi. Test specimens from welded joints had an ultimate strength of 81,000 to 84,000 psi. and a yield stress of 53,000 to 56,000 psi.

As the platforms are resting loosely on brackets welded onto the piles, all connections can be considered as hinges. The structure is so flexible, that under the maximum forces the slope of the timber fendering exceeds the probable tilt of the ship. For this reason it was assumed that the point of load application for wind thrust and impact forces will shift to the elevation of the lower platform.

Except for loading Case (b), the loads have been assumed uniformly distributed to all dolphin piles.

The penetration depth of the piles was determined following the methods used for cantilevered steel sheet piling. The soil between the piles was included in the effective width which appeared to be a justified assumption considering the 7 ft.-6 in. centre-to-centre spacing of the piles.

For calculations of the soil resistance the following soil properties were used: *(see equation I)*

In order to have a consistent overall factor of safety, the penetration depth was designed for a theoretical lateral force on structure, required to produce simultaneous yield of steel and ultimate soil resistance.

A summary of calculations for the main dolphins is shown in equation II as well as in Fig. 5.

Actually the specified penetration depth was made 8 ft. greater than the theoretically calculated 37 ft., to provide some allowance for the uncertainties in soil conditions.

The bending moment diagram, shown for 1 ft. width of structure, allows to compute moments and corresponding deflections and stresses for various design loads by use of coefficients.

The greatest lateral force was found to be a wind thrust of 90 T. per dolphin. Corresponding maximum bending moment per pile:

Equation III

$$M = 4415 \frac{17.5 \times 90}{7 \times 130} = 7640 \text{ in. t.}$$

Stress

$$f = 31200 \text{ psi.}$$

Deflection $$d_A = \int_0^A \frac{M_y Y dy}{EI_y} = 11.3'$$

It was found convenient to determine first the deflection for a load of 1T per pile $d_{A1} = 0.88''$ and use it as a basis for further calculations.

The highest stresses in piles were found to be due to eccentric impact forces. *(see equation IV)*

The twist of the structure is represented by an angle θ. Except for the center pile, all other piles undergo a displacement of $R \times \theta = 90\,\theta$ in. Total torsional moment on six piles. *(see equation V)*

Since the structure undergoes torsion and bending at the same time, the sum of both energy quantities represents the total energy absorbed by the structure. *(see equation VI)*

It should be noted that the deflections were defined assuming that the effective point of fixation coincides with the point of maximum moment. It could be expected that the effective resistance of the soil changes as the lateral load is increased. Although the point of maximum moment remains at essentially a fixed elevation, the effective point of fixation moves downward as larger loads are applied. Consequently the extreme

Equation I

Submerged weight of soil	$w = 65$ lbs. per cu. ft.
Angle of internal friction	$\phi = 30$ degrees
Cohesion	$c = 0$
Factor to allow for wall friction in Rankine's value of coefficient of passive earth resistance	$m = 1.33$

Equation II

Soil pressure increment per 1 ft. of depth	$mp_p - p_a = 238$ lb./ft.²
Effective width	$B = 17.5$ ft.
Required M.R. of soil for 1 ft. width, based on yield strength of piles	$M_r = 736{,}000$ ft. lb.
Maximum bending moment for piles is at depth	

$$X_0 = \sqrt{\frac{2H}{mp_p - p_a}}$$

$$\max M = M_r = H\left(42 + \sqrt{\frac{H}{119}}\right) - \frac{238}{6}\left(\sqrt{\frac{H}{119}}\right)^3 = 736{,}000 \text{ ft. lb.}$$

$H = 14860$ lb. $= 7.43$ T. $\qquad X_0 = 11.2$ ft.

Corresponding force on structure $\qquad F = 7.43 \times 17.5 = 130$ T.

From equation

$$X^4 - \frac{8H}{mp_p - p_a}X^2 - \frac{12Hh}{mp_p - p_a}X - \left(\frac{2H}{mp_p - p_a}\right)^2 = 0$$

necessary penetration $\qquad X = 36.93$ ft.

Equation IV

Energy absorbed by structure in bending only $\qquad E_B = 0.5\frac{0.88}{7}F^2 = 0.0629F^2$ in. t.

Energy absorbed by six piles in torsion $\qquad E_T = 0.5 M_T \theta$

Assuming force F acting on structure with 4 ft. eccentricity $\qquad M_T = 48F$ in. t.

Equation V

$$M_T = 6\frac{90\theta}{0.88} \times 90 = 55300\theta \text{ in. t.} = 48F \qquad \theta = 0.00087F \text{ (Radians)}$$

$$E_T = 0.5 \times 48F \times 0.00087F = 0.0209F^2 \text{ in. t.}$$

Equation VI

$$E = E_B + E_T = (0.0629 + 0.0209)F^2 = 0.0838F^2 \text{ in. t.}$$

Energy from ships impact

$$E = 0.5 \times 0.5 \times \frac{mv^2}{2g} = 23.4 \text{ ft. t.} = 282 \text{ in. t.}$$

say 300 in. t.

Force on structure $$F = \sqrt{\frac{300}{0.0838}} = 59.9T$$

Maximum displacement of a pile at EL. + 8.0 ft.

$$d = \frac{0.88}{7}59.9 + 0.00087 \times 59.9 \times 90 = 12.22 \text{ in.}$$

Maximum force on a pile $$F = \frac{12.22}{0.88} = 13.9T$$

Maximum stress $\qquad f = 36200$ psi.

deflections could be expected larger than calculated.

For the design of end dolphins a static pull, governed by the breaking strength of 8 in. ropes was considered. According to the marine experts a vessel may have up to three 8 in. manilla ropes tied on a bollard of the dolphin. The breaking strength of one rope is 21 tons. Since it is unlikely that all ropes will be stressed to the same extent and near their breaking strength, it appeared to be justified to use a design load of 30 tons. The calculated maximum bending stress from this load was 36,000 psi. and the maximum deflection for the structure at El. + 26.0 ft. was 20". Comparative calculations were made combining the effect of a wind force on ship and the drag from a current of 3.5 knots. Assuming this force equally distributed to one main dolphin and one end dolphin, the resulting force on an end dolphin was 28 tons.

The platforms were designed as diaphragms, each made up of a single ⅜ in. thick checkered steel plate with stiffeners. A tolerance of ±6 in. was allowed for locating each individual pile in plan, which later proved to be adequate. Creosoted B.C. fir timber fendering was used in front of the dolphins as shown in Fig. 2. To lessen the effect of glancing blows on the structure, the fendering was curved towards the sides of the dolphins. Each dolphin was also equipped with steel ladders and handrailing.

Construction of Dolphins

The main construction problem was the driving of the large diameter piles. Ultimate pile resistance was expected in the range of 200 to 300 tons, therefore, driving equipment had to be of the heaviest type.

An open end tubular pile may act during driving like a closed one, because of the clogging of soil inside the cylinder. The jetting of piles was not desirable because of possible soil disturbance. The heaviest locally available double acting steam hammer with 20,000 ft. lb. energy per blow was considered to be inadequate for this job. For all practical purposes, driving with a heavy drop hammer appeared to be the best solution. In order to avoid reinforcing the pile head, the driving was carried out with a hammer, dropping inside the pile cylinder and delivering the blows to a 5 ft. long concrete plug, poured at the bottom of the pile.

Fig. 8 Complete Installation of Mooring Dolphins

This method offered good control over the plumbness of the pile during driving. Also, the energy of the hammer was used more efficiently when applied at the pile tip. In some respects this unconventional driving method is associated with the principles used for caisson-pile driving. In fact, the largest type pile driving rig, equipped with a hammer of 8,000 lbs. weight, was used for the job. The method chosen simplified the pile preparation and generally proved to be successful. As it was not certain that a conical pile tip would ease the expected heavy driving the pile was constructed for simplicity and economy with a flat end.

The 105 ft. long piles were fabricated and shipped to the site in units of 50 ft. and 55 ft. lengths. Concrete of 3,000 lb. strength with 15% additive by weight of cement was used for the plugging of the 55 ft. long bottom units. After a hardening period of 3 days the pile units were moved to the welding bed for splicing. Prior to welding, the material was preheated to 450°F. by means of a burner coil. The preheating temperature was controlled by use of heat sensitive crayons. To slow down the cooling of the material, the joint was kept covered with asbestos blankets for 2 hrs. after welding. All field welding was carefully inspected and a number of radiograph films were made to check the quality of the welding.

The upper end of the pile was temporarily sealed off and the whole pile assembly weighing 12 tons was floated to the site at high tide by use of two pontoons equipped with air winches as illustrated in Fig. 8.

Fairly accurate location of the piles was obtained by means of markers on the shore and markers and templates fixed on the barge. The barge, carrying the driving rig, was moved into the final accurate location by use of four air winches, adjusting the length of four anchor cables from the barge. Prior to the pile driving, a packing of sand and crushed stone was placed on top of the concrete plug to cushion the hammer blows. More packing was added from time to time during the driving as soon as it was noticed by sound that the packing had been pulverized and compacted to the point where it no longer acted as a cushion. Up to 16 ft. of packing was used for some of the piles.

In general, the hardest driving was experienced for the last 20 ft. of the total penetration of approximately 50 ft. Fig. 7. shows the driving energy used for penetration of one of the main dolphin piles, which may be considered as typical for the majority of the piles. It is questionable whether any of the known dynamic pile driving formulae is applicable in this particular case. It could be expected that a great deal of energy was absorbed by compaction of the packing and elastic deformations of the pile. It was estimated that the ultimate resistance of a pile is in the neighbourhood of 300 tons. Several piles were inspected visually from the inside after completion of the driving. Inspection did not reveal any sign of damage to the pile, nor any noticeable deformations. The average time for locating and driving of a pile was one day. Most of the driving was accomplished in 4 hours per pile. Templates were made to fit the as-driven pile locations. The platforms were then assembled on the shore from prefabricated elements using these templates.

The platforms and all external surfaces of the piles were painted with a coal tar paint applied in two coats. In addition to that, a sacrificial magnesium anode system was installed. It is expected that this system will be replaced by an impressed current

(Continued on page 54)

DEVELOPMENT OF WATER RESOURCES IN ONTARIO

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Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June, 1959.

A MAJOR CHANGE in the administration of water and sewage works has been introduced in Ontario. It involved the creation of a Water Resources Commission, along with the adoption of appropriate legislation. Since this Act came into force in 1956, the program of the Commission has expanded and it is now feasible to assess what has been accomplished, as well as to discuss some of the plans proposed for the future. It is believed that this program in Ontario is unique, both on this continent and elsewhere. It recognizes certain principles which are of the utmost importance in the development and orderly progress of any country. An outline of the Commission's program and objectives is included in this paper.

This new procedure in Ontario recognizes the important role played by water resources. The events preceding this action pointed clearly to the significant requirements of the Province for water supply for all areas where growth is to be expected. It showed clearly that water resources must be conserved against the ravages of pollution from sewage, industrial wastes and other substances, which may impair water quality and interfere with repeated use. The relationship between water supply and pollution is made clear by the overall objectives of the Commission.

This new program resulted from a number of factors which had developed over a period of time. A better understanding of this activity may be had through an analysis of some of the conditions which brought about this change in policy. Ontario has a population in excess of 5½ millions. It covers an area of 412,582 square miles, out of a total of 3,845,794 square miles for all Canada. The scattered distribution of population creates problems where community projects are involved. Southern Ontario has the highest concentration of population and has been a focal point for industrial growth. Opportunities for this continued growth are great, but the associated problems also are great.

It is recognized that growth and human betterment cannot be sustained unless there are adequate water supplies. These supplies are one of the greatest national assets, and the quality must be protected at all costs. The importance of the Great Lakes system to southern Ontario is clearly evident. Large communities and industries have been attracted to these waters over a period of many years. Now as the growth moves inland, the adequacy of water and the prevention of pollution take on new significance.

Inland communities in much of southern Ontario are faced with water problems including quantity, quality and pollution control. Rapid run-off and resulting low stream flows in the summer months, combine to make pollution a serious problem when these watercourses are needed to serve their normal functions. Costs for the development and transportation of water have risen sharply, and high interest rates have added further to this difficulty. It is even more essential to protect local water supplies from pollution when the expenditure for others is so great. When water must be piped long distances, or when the most economical arrangement is necessary in sewage and waste disposal, there is an advantage in dealing with these on a regional basis for a number of municipalities rather than having each attempt to solve its own problems separately. Individual efforts in the past have not led to the most effective solutions.

By 1955, the need for water supply and sewage treatment works was sufficiently urgent to call for action at the Provincial level. This was especially true in southern Ontario where a major post-war growth had been experienced, and where there was every promise of a continuance of this expansion if no serious restrictions or barriers were placed in the way. Adequate water resources of good quality were recognized as a primary need for insuring this continued growth and the welfare of the Province. The interrelationship of waste disposal and availability of water supplies was conceded in the program which was to be adopted by the Province.

Action by the Government

The adverse conditions which might well develop in relation to water resources were foreseen by the Government of the Province, and a Water Resources and Supply Committee was appointed in 1955 to inquire into and to advise on a constructive program. The Committee consisted of five members under the chairmanship of Mr. A. M. Snider. The Committee's report of that same year was followed immediately by legislation made effective in April of 1956, and through which a Water Resources Commission was appointed consisting of five men under the same Chairman. This first legislative enactment authorized the development of an organization and necessary procedures for carrying out the program. This bill was considerably altered in April of 1957 under the title "The Ontario Water Resources Commission Act, 1957". Some further amendments were made in 1958. These various actions provided the means for the Commission to proceed aggressively on its objectives.

The Ontario Water Resources Act

The broad scope of the authority given to the Commission is set out in Section 16 of The Ontario Water Resources Commission Act, which reads as follows:

"Notwithstanding any other Act, it is the function of the Commission and it has power,

(a) to control and regulate the collection, production, treatment, storage, transmission, distribution and use of water for public purposes and to make orders with respect thereto;

(b) to construct, acquire, provide, operate and maintain water works and to develop and make available supplies of water to municipalities and persons;

(c) to construct, acquire, provide, operate and maintain sewage works and to receive, treat and dispose of sewage delivered by municipalities and persons;

(d) to make agreements with any one or more municipalities or persons with respect to a supply of water or the reception, treatment and disposal of sewage;

(e) to conduct research programs and to prepare statistics for its purposes; and

(f) to perform such other functions or discharge such other duties as may be assigned to it from time to time by the Lieutenant-Governor in Council. 1957, c.88, s.16".

The major features of this legislation may be considered under two parts, one dealing with the supervision by the Commission over all water and sewage works in the Province; the other having to do with the construction of water and sewage projects by the Commission for municipalities and others. Some features of these two parts of the program may be of interest at this time.

For many years the Ontario Department of Health under public health legislation had exercised supervision over public water and sewage works built and maintained by municipalities or persons. This was similar to what was done in other provinces of Canada, and in most of the States. Under The Water Resources Commission Act, legislation contained in The Public Health Act was not only transferred to the Commission, but was considerably expanded and altered to permit more effective control. This was especially so in relation to stream pollution.

This new program for water and sewage works construction is a distinct departure from the procedures of the past. It is believed to be also different from practices followed in other countries. The object was to help municipalities meet their demands for these utilities. The Commission offers financial advantages as well as expert technical assistance in the planning, construction, and operation of the works. This procedure obviates the need of the municipality to issue any bonds or to borrow any money for the works.

Construction Procedures Under the OWRC

The procedure followed by the Commission in its program of constructing these water and sewage projects has several new features not otherwise utilized in Ontario.

1. In the first place, any municipality is free to decide whether it wishes to do its own work, or whether it desires to place this under the Commission. The services of the Commission are available to any municipality, but there is no effort made to urge a municipality to place a project under the OWRC. The chief desire of the Commission is to see that the work goes forward. If the municipality so requests, an agreement can be made between the corporation and the Commission under which the latter undertakes to design, build, finance, and operate the water or sewage project. A standard form of agreement is used, subject to minor alterations to meet local conditions. This agreement on a project may involve one or several municipalities as well as industries. It may concern very small works or very large ones. Particular emphasis is placed on joint projects which will serve a number of municipalities, whether these be for water supply or sewage disposal.

2. Projects undertaken by the Commission are, in general, confined to works for the supply, purification, and delivery of water through feeder mains to the contracting party's distribution system, or to trunk sewers, treatment works and sewer outfalls. It is only in the case of small communities that the Commission undertakes the construction of the local water distribution mains or the sewage collection system. In those instances there is a definite advantage to have all the work done under the one contract and under one management.

3. When the agreement has been approved by both parties, the Commission goes forward on the necessary plans and specifications. The policy of the Commission has been to appoint consulting engineers to do the design work and also to do field supervision during construction. Thus, the consulting engineer is an employee of the Commission rather than the municipality. He engages the resident engineers and field staff to supervise construction. The Commission on its own maintains a construction branch to deal with this work and to ensure that the project is carried out to its satisfaction.

4. All contracts for these projects are awarded by the Commission, and the complete program is under the direct responsibility of the Commission. Payments are made to the contractor as work progresses, also to the suppliers of equipment and to the consulting engineers. In this way, no payments are made by the contracting municipality until the works are in operation.

5. The agreement between a municipality and the Commission is based on the latter assuming responsibility for the operation and maintenance of the works during the lifetime of the debt. When the project is constructed, the responsibility of this passes from the construction division of the Commission to the operating division. The personnel for these operations are engaged by and paid for by the Commission. Where there are small works, and these do not require the services of a full-time staff, arrangements may be made to employ on a part-time basis some of the local employees of the municipality or others as the case may be.

6. The agreement between the municipality and the Commission contains a clause whereby at the termination of the debt, the works may be returned to the municipality at the request of either party. Extensions or enlargements of the works may be made by the Commission at the request of the municipality and in this way, the debt retirement period may be extended for a longer period. Each of these extensions involves a new agreement between the Commission and the municipality, and the Commission would not have the right to extend the original works under the terms of the first agreement.

7. An important part of this entire program is the means for co-operation between the Commission and the municipalities served. Each municipality is asked to appoint a local advisory committee to work with the Commission and to deal with all aspects of

the program. In this way there is a local direction for such matters as appointment of employees, wages paid, and many other features of administration. This tends to relate the activity to local conditions rather than having one set of standards or requirements for the entire Province.

8. The Commission offers to each municipality extensive services in the operation of the works. There is the closest co-ordination of all technical matters in which the advice of the local engineering staff is combined with the specialized training of the Commission's personnel. In small municipalities where new works are being installed and where there has been little local experience on such matters the Commission advises on all aspects of the administration, including rate structures, bookkeeping, records, etc. In this way, full use is accorded each municipality of the Commission's laboratory facilities and its technical staff without cost to that community.

Financing Commission Projects

The financial arrangements for the projects constructed and operated by the Commission are an important part of the overall program. Stringent money conditions including difficulty of raising loans, and high interest rates have added to the burdens of municipalities in financing undertakings on their own. Under the plan offered by the Commission, the municipality does not issue or sell any debentures or bonds. Money is advanced by the Commission, and the credit of the Province is pledged for this. The debt is paid back over a long period, 30 years in most instances but varied according to the wishes of the municipality. The interest rate is the actual cost of money borrowed by the Province. This rate is normally lower than it is possible for the municipality to obtain on the open market. The indebtedness of the Commission can be met by the sale of its own bonds, which are guaranteed by the Province, or it can horrow directly, as it has to date, from the Provincial Treasurer, thereby gaining the advantage of borrowings on a large scale.

A number of advantages can be found in this method of financing in addition to the more favourable interest rate. One is the flexibility of the agreement. The municipality makes no payment to the Commission until the work is put into operation. The debenture period may be made to suit local needs. Principal payments may be deferred at the outset and up to a period of five years after the work is completed. The interest rate will vary each year, and as the prevailing high interest rate is lowered, the municipality obtains this advantage of further saving.

In Ontario, all financial obligations to be incurred by municipalities come under the supervision of the Ontario Municipal Board. The Board thus determines whether the obligation is within the ability of the municipality to carry. This same requirement applies whether the municipality is doing the work on its own, or whether the work is under The Ontario Water Resources Commission. In the latter instance, the Commission deals directly with the Board for the municipality.

Where a number of municipalities or other parties are concerned with a single project, the agreement provides for allocation to each of these that part of the capital debt for which they will be responsible to the Commission. The cost of the water delivered or the sewage treated is based on this and the actual cost of operation. At present, the Commission is undertaking sewage projects in which a number of municipalities will be provided joint service including the trunk sewers and the treatment facilities.

The basis of all financial agreements with municipalities is that they shall pay to the Commission the actual cost of the debt and service rendered. The latter does not include the supervisory services of the Commission, but only those operators actually engaged on the project. No money grants are involved in these programs. The contracting municipality will pay quarterly to the Commission the estimated amount of capital and operating charges as well as a reserve fund for contingencies, repairs and replacements. At the end of the year an adjustment is made with the actual costs for that period. These financial procedures relieve the municipality of all details involved in borrowing money for capital works.

Sanitary Supervision over Sewage Works

The other part of the Commission's program involving sanitary supervision over sewage plants as well as water utilities is similar to that which is normally carried out under a Provincial health department. All plans for water and sewage works installations, or extensions to existing works require the approval of the Commission before construction is undertaken. In this way, the Commission is given wide powers to deal with the water resources of the Province, and has the right to regulate water use.

Great emphasis is placed on the control of stream pollution. If water resources are to be made available for the maximum use and public benefit pollution control must be exercised rigidly. The Commission, under the legislation is empowered to deal with the protection of all water supplies. Heavy penalties are provided for infringement of this. A departure from the usual public health provision against pollution is that under the Commission's program this is not to be confined to something which may only affect public health, but rather is it widened to include anything which may impair the quality of the receiving watercourse. A good deal of the activity of the Commission since its inception has been devoted to sewage and waste disposal and to the abatement of stream pollution.

Organization of the Commission

The Commission's program has been organized to give effect to these various activities. The Commission, at present consisting of six members, decides on all matters of policy. The administration of these policies comes under a General Manager acting through six divisions or branches. These consist of Administration, Laboratories & Research, Construction, Plant Operations, Sanitary Engineering, and Water Resources. The staff has grown at a rapid rate, and at present is nearly 200. A new laboratory is near completion to serve the needs of the Commission and to give service to all municipalities operating water and sewage works. Research programs will be emphasized in this laboratory, and there will be full co-operation with industry and with municipalities.

Progress Under the Commission

The program of the Commission is as yet in its early stages. The act of the Legislature came into effect only in April 1957. Since that time it is gratifying to note the number of projects which have been undertaken. To date agreements have been made with municipalities for 65 projects for works involving an estimated expenditure of approximately $33,500,000. These include 32 water projects and 33 sewage works. Twenty-one of these are already in operation, others are in various stages of development. In many other instances agreements

(Continued on page 54)

HYDRAULIC PROBLEMS IN CONNECTION WITH THE DEVELOPMENT OF THE ST. LAWRENCE RIVER

H. W. Lea, M.E.I.C., *Consulting Engineer, formerly Alternate Member, Canadian Section, St. Lawrence River Joint Board of Engineers.*

ALTHOUGH the St. Lawrence River is noted amongst the larger rivers of the world for the fact that its maximum discharge is only about twice the minimum discharge, nevertheless many useful purposes would be served by the achievement of greater regularity of flow by some practical and suitable means of control.

Disregarding for the present purpose the fluctuations in water levels of the four Great Lakes upstream from Lake Ontario with the consequent storage which results, it became apparent from study of records which have been kept for the past 100 years, that there has been continuous variation in the level of Lake Ontario which has shown a total range of about six and a half feet. This represents a very large volume of water when translated into terms of river flow, and if advantage, so far as practical, is taken of that storage the regime of the river can be materially improved, particularly during periods of low natural discharge.

The portion of the water shed of the St. Lawrence tributary to the Great Lakes is international in character and this situation persists in the International Rapids Reach where the river itself is the international boundary until the latter deviates to the southward away from the river, near the head of Lake St. Francis just downstream from Cornwall. A plan of this reach is given in Fig. 1.

Any actions taken which will interfere with the natural flow of the St. Lawrence upstream from where it ceases to be the international boun-

Fig. 1. St. Lawrence project—International Rapids section.

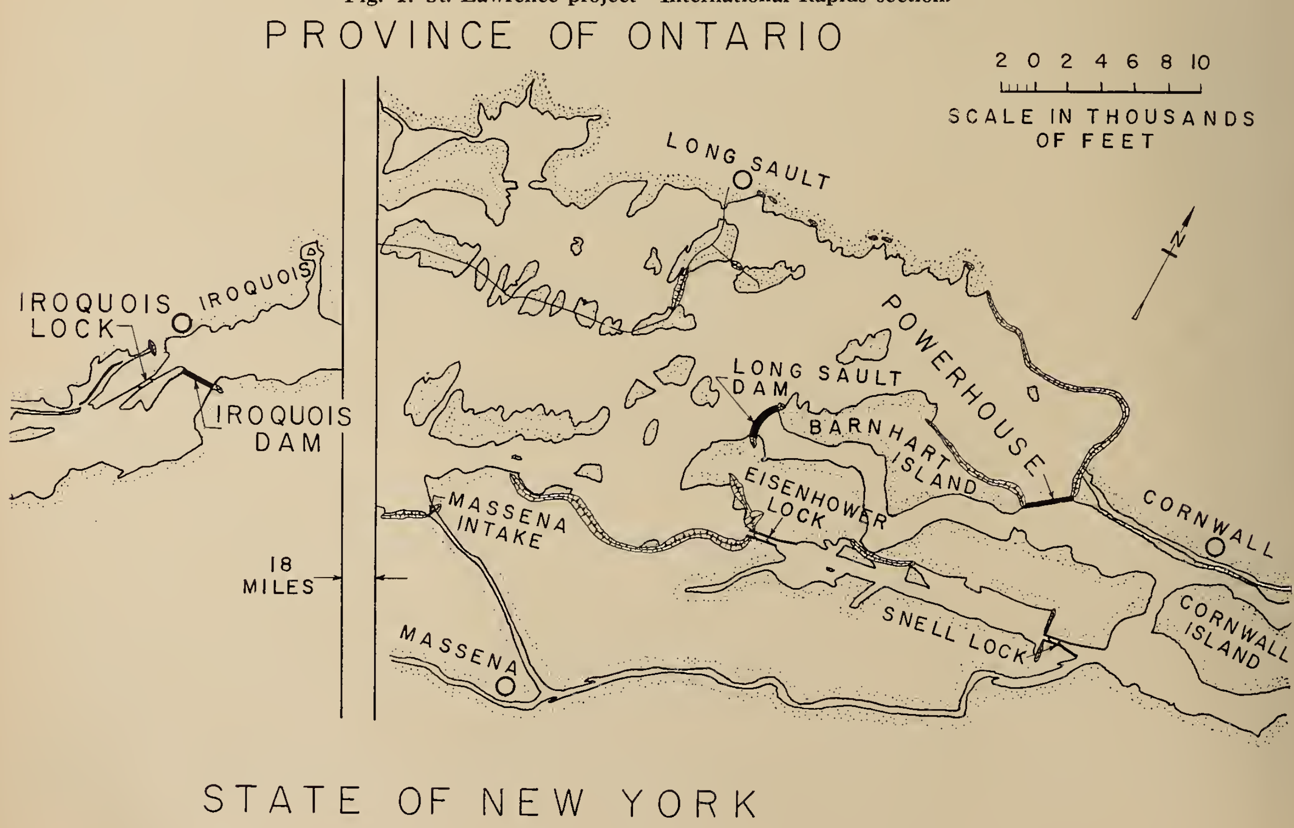

Fig. 2. St. Lawrence project—Soulanges section.

dary must be in accordance with the wishes of the people of the two nations as agreed upon by their governments. It will also be understood that any measures of control which are initiated in the international section of the river must be so devised that they would do no harm to any legitimate interest on that portion of the river downstream from the international boundary, which is an exclusively Canadian river.

The problem of development of the international section of the St. Lawrence for navigation and power had been under active study for more than half a century and many attempts had been made to secure agreement between the United States and Canada on a joint scheme of development. Eventually, lacking achievement of such agreement, Canada decided to proceed with an all-Canadian seaway which provided for such canal sections and locks as would be required in the international section of the river to be constructed on the Canadian side. At the same time there was an urgent demand for hydro-electric power from both sides of the border and it was recognized that the development of such power in the international section would greatly reduce the problem of design and construction of deep-draft navigation facilities. Consequently the two national Governments decided to refer the question of development of the International Rapids Section of the river for both navigation and power to the International Joint Commission with the objective of the issuance of an Order of Approval by that Commission on the premise that the construction of all navigation facilities would be on the Canadian side and would proceed concurrently with those for hydro-electric power development.

An Order of Approval was issued by the IJC in the fall of 1952 and when it became patent that Canada intended to complete the navigation facilities as quickly as possible the United States decided, as was the right of that country, to participate in the navigation development, and the United States Wiley-Dondero Bill which was passed in 1954 provided for construction of a canal on the American side of the river leading downstream from the power pool above Long Sault Dam to the international channel south of Cornwall Island, which leads into Lake St. Francis.

As a result of many representations from both countries over the years with respect to control of the levels of Lake Ontario and the outflows through the St. Lawrence River the two Governments, previous to the joint submission on development of the International Rapids Section, decided upon a reference to the International Joint Commission requesting a study and report on those subjects. The International Joint Commission thereupon established a Lake Ontario Board of Engineers to investigate and report to the Commission on the engineering aspects of the problem. This engineering study had hardly begun at the time of the joint submission to the Commission of the St. Lawrence Project in the International Rapids Section.

Many complaints had been received by both countries on both high water levels and low water levels on Lake Ontario and on low flows in the river. Since the maximum natural range of stage in Lake Ontario, as previously noted, is not more than about six and a half feet it was necessary to approach with extreme care the feasibility of reducing this range of stage in order to satisfy in part the wishes of all the complainants regarding extreme high and low lake levels, and variations in river flows. Eventually, the Lake Ontario Board of Engineers reported that it would be possible under regulation to reduce the range of stage of Lake Ontario to about four feet and the IJC accepted the advice of its Board and set the range of stage at, from a minimum of elevation 244, during the navigation period, to a maximum of elevation 248.0, as near as may be.

These figures may be compared with a recorded minimum elevation of 242.7 during the navigation season and a maximum elevation of 249.3.

The original IJC Order of Approval provided for the establishment of two international engineering boards and set out the duties and responsibilities of these boards in connection with the development of the international section of the river and operation of the control facilities:—

The St. Lawrence River Joint Board of Engineers.

This Board was established in late 1953 and is composed of 2 members and 2 Alternate Members for each country, whose duties are to review, co-ordinate, and approve on behalf of the two Governments the plans, specifications and schedules of construction of the works to be constructed by the Power Entities in the International Rapids Reach and to ensure their construction in accordance therewith.

The International St. Lawrence River Board of Control.

This Board, established in late 1953, is composed of 4 Canadian and 4 U.S. Members—increased from 3 from each country in 1958—which during the construction period is keeping the International Joint Commission informed as to the outflow and levels of Lake Ontario and co-operating to this end with the St. Lawrence River Joint Board of Engineers, and upon completion of the works is to insure that the provisions of the Order relating to water levels and the regulation of the discharge from Lake Ontario and the flow of the water through the International Rapids Section, as set out therein, are complied with. Later, in 1956, this Board was instructed to take over the study of the regulation of Lake Ontario, which until that time had been carried on by the International Lake Ontario Board of Engineers.

Subsequent to the issuance of the original IJC Order of Approval, which was accepted by both Governments, as a result of detailed investigations and studies by the Lake Ontario Board of Engineers and by the Board of Control which led to engineering recommendations to the IJC, a Supplementary Order of Approval was issued in the summer of 1956. This Supplementary Order set out a series of detailed criteria which were designed for appropriate and reasonable protection of all legitimate interests on the river both upstream and downstream from the works to be constructed, and detailed regulation of the flow of the river must at all times fulfil the conditions set out in the criteria.

These criteria are as follows:—

(a) The regulated outflow from Lake Ontario from 1 April to 15 December shall be such as not to reduce the minimum level of Montreal harbour below that which would have occurred in the past with the supplies to Lake Ontario since 1860 adjusted to a condition assuming a continuous diversion out of the Great Lakes Basin of 3,100 c.f.s. at Chicago and a continuous diversion into the Great Lakes Basin of 5,000 cubic feet per second from the Albany River Basin (hereinafter called the "supplies of the past as adjusted").

(b) The regulated winter outflows from Lake Ontario from 15 December to 31 March shall be as large as feasible and shall be maintained so that the difficulties of winter power operation are minimized.

(c) The regulated outflow from Lake Ontario during the annual spring break-up in Montreal Harbour and in the river downstream shall not be greater than would have occurred assuming supplies of the past as adjusted.

(d) The regulated outflow from Lake Ontario during the annual flood discharge from the Ottawa River shall not be greater than would have occurred assuming supplies of the past as adjusted.

(e) Consistent with other requirements, the minimum regulated monthly outflow from Lake Ontario shall be such as to secure the maximum dependable flow for power.

(f) Consistent with other requirements, the maximum regulated outflow from Lake Ontario shall be maintained as low as possible to reduce channel excavations to a minimum.

(g) Consistent with other requirements, the levels of Lake Ontario shall be regulated for the benefit of property owners on the shores of Lake Ontario in the United States and Canada so as to reduce the extremes of stage which have been experienced.

(h) The regulated monthly mean level of Lake Ontario shall not exceed elevation 248.0 with the supplies of the past as adjusted.

(i) Under regulation, the frequency of occurrences of monthly mean elevations of approximately 247.0 and higher on Lake Ontario shall be less than would have occurred in the past with the supplies of the past as adjusted and with present channel conditions in the Galops Rapids Section of the Saint Lawrence River. ("present channel conditions" refers to conditions as of March 1955.)

(j) The regulated level of Lake Ontario on 1 April shall not be lower than elevation 244.0. The regulated monthly mean level of the lake from 1 April to 30 November shall be maintained at or above elevation 244.0.

(k) In the event of supplies in excess of the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to the riparian owners upstream and downstream. In the event of supplies less than the supplies of the past as adjusted, the works in the International Rapids Section shall be operated to provide all possible relief to navigation and power interests.

It should be noted at this point that the various bodies that have been referred to herein have been concerned exclusively with development of the international section and control of the levels of Lake Ontario and St. Lawrence River flows. With respect to navigation, construction and maintenance of the St. Lawrence channel below Montreal has been for many years the responsibility of the St. Lawrence Ship Channel Service of the Department of Transport and ships with draft up to 35 ft. are using the Port of Montreal regularly. Above Montreal the St. Lawrence Seaway, which has previously been the subject of numerous papers and articles, envisages a channel depth of 27 ft. and maximum ship draft of 25 ft. up to Lake Ontario, and through the Welland Canal to Lake Erie; while additional programs are under way to provide for these depths up to the head of the Lakes. The St. Lawrence Seaway Authority is charged with responsibility for construction, maintenance and operation of the Canadian portion of the seaway while the St. Lawrence Seaway Development Corporation is the parallel United States organization.

In the international section basic requirements of navigation channels are contained in the IJC Order of Approval and the details of the channels are being completed along lines which have been approved by the Joint Board of Engineers. In the Canadian section of the river the Government of Canada is directly concerned only with navigation matters and consequently the St. Law-

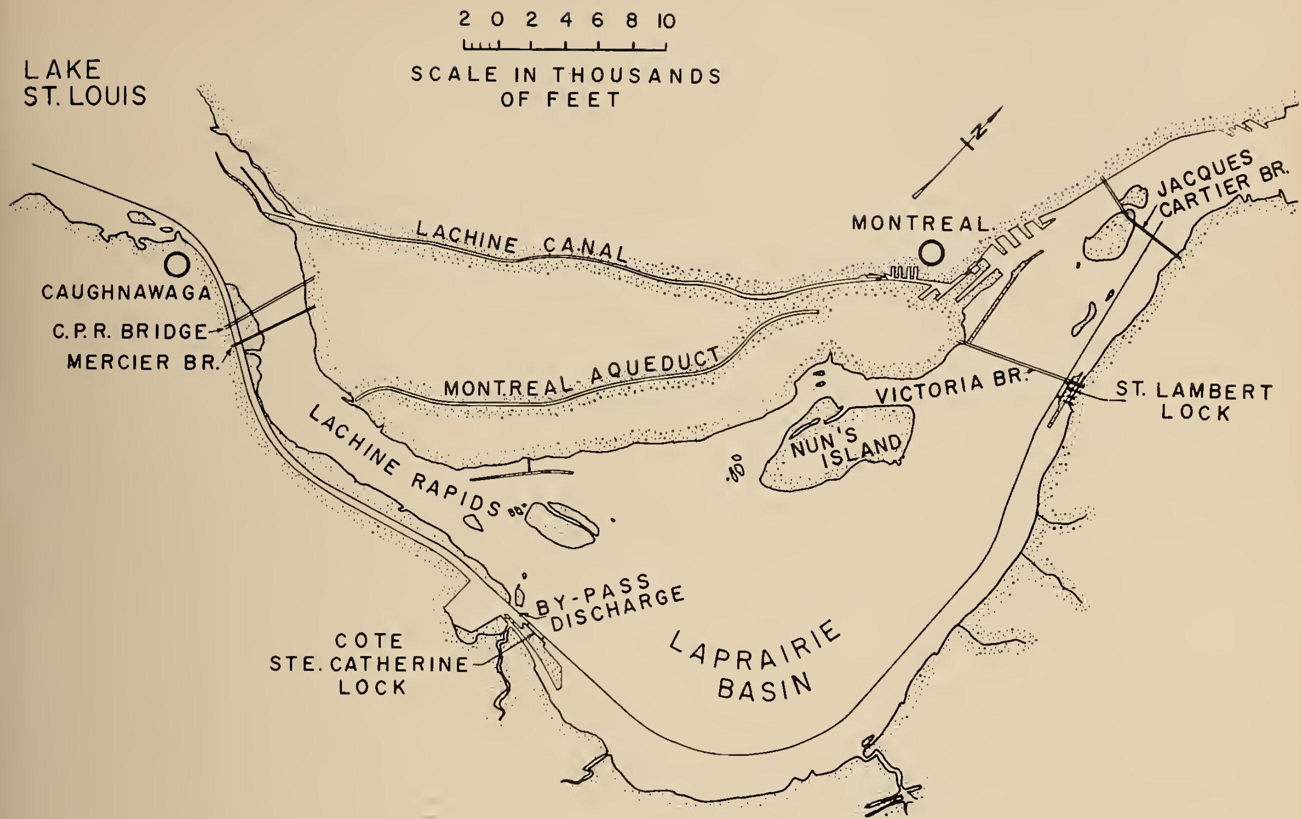

Fig. 3. St. Lawrence project—Lachine section.

rence Seaway Authority has worked closely with Quebec-Hydro wherever each body has an interest in the program.

Insofar as the international section is concerned, the IJC Order of Approval requires that average velocity in the navigation channel shall not exceed 4 feet per second during the navigation season, and shall not exceed 2¼ ft. per second during the ice-forming period. Generally speaking, channel improvements which fulfil the second requirement mentioned above also fulfil the first. Therefore no substantial problem has been met in creating a satisfactory navigation channel while work is being carried out for the purpose of providing satisfactory hydraulic conditions.

Below the Long Sault Dam and the Powerhouses the river divides into two channels flowing to the north and to the south of Cornwall Island. The large scale excavations which were required to provide a seaway channel south of Cornwall Island, which became necessary when it was decided to install locks on the United States side of the river, altered the balance of discharge of the two channels. Thus compensatory excavation was required in the channel north of Cornwall Island in order to maintain the natural distribution of flow. These operations lowered the average elevation of the tailrace at the Powerhouses by more than a foot, which increased dependable power production by a substantial amount. By agreement between the Power and the Seaway Entities the former undertook to pay to the latter a lump sum of 12 million dollars in recognition of the increased head made available on the turbines. At this point, it may be of interest to remark that Canada has also agreed to pay a lump sum of 15 million dollars to the Power Entities towards the cost of navigation improvements in the International Rapids Section.

When the Beauharnois power development was begun the power company undertook to provide a depth of 27 ft. in a section of the power canal 600 ft. in width, throughout its length and this channel has now been incorporated in the St. Lawrence Seaway by the installation by the St. Lawrence Seaway Authority of locks adjacent to the Powerhouse leading from the canal to Lake St. Louis. Fig. 2 shows a plan of the Beauharnois Canal.

When hydro-electric power is developed at Lachine Rapids it will be necessary to undertake a large scale excavation program above the existing rapids in order to reduce forebay velocities during the ice-forming period to the extent which will ensure formation of a suitable and satisfactory ice cover. Ledge rock is found at or near ground surface throughout this area and excavation will be costly. The Seaway, as it leaves Lake St. Louis is located very close to the south bank of the river and restricts the width to which excavation could be conveniently carried out in the dry along that shore. Consequently, when constructing that portion of the canal which extends from Lake St. Louis to Laprairie Basin the St. Lawrence Seaway Authority, at its own expense, designed the canal prism to be capable of carrying a flow of 40,000 c.f.s. from Lake St. Louis, and provided the necessary structures above Cote Ste. Catherine Lock to discharge this flow into Laprairie Basin. There will be no interference with navigation since the ice-forming period does not occur until after the annual navigation season is finished. Thus Quebec-Hydro will be relieved of excavation which otherwise would be required to carry a flow of 40,000 c.f.s. A plan of the Lachine Section is shown in Fig. 3.

Optimum requirements for Domestic Use, Navigation and Power, and protection of Riparian Owners, as well as economic considerations were frequently at variance during solution of these hydraulic problems. Careful analysis and considerable give and take were required to reach fair and reasonable decisions. The study of some of these problems must be continued with a view to improvement in procedures as more knowledge is gained and it may be anticipated that such studies will continue for many years before all the problems are finally resolved.

MOORING DOLPHINS *(Continued from page 46)*

cathodic protection installation, following the construction of any future wharf extension.

The B.C. Fir pressure creosoted timber fendering units were prefabricated on the shore and later fastened on brackets of the dolphin steelwork.

The field work for all four dolphins, including the pile preparation, required three months' time. The work on water was very much affected by the tide conditions.

The installation was completed on 25th July 1958. Fig. 8. shows a general view of the completed mooring installation.

Since the completion of installation several ships have used the new mooring facilities. None of the ships has been moored during extremely rough weather, but moderate winds have been experienced. During one of the mooring operations, repetitive pulling forces due to the tightening and slackening of lines produced 18" deflection of the northern end dolphin. However, no permanent deflections have been observed. It could be expected that the 300 ft. distance between the main dolphins will be to greater advantage for the future large cargo vessels than for the present ships of medium size. The present general experience indicates that the installation provides a satisfactory service.

Acknowledgments

The design and detail construction drawings were prepared by the General Engineering Department staff of the Aluminum Company of Canada, Limited, under general direction of J. F. Braun, M.E.I.C., Chief Civil Engineer. The General Contractor for this work was Saguenay-Kitimat Company. Mr. H. C. Jenkinson, Vice President of the company, directed the work in field. Franki of Canada Limited was engaged as subcontractor for the pile driving work and Mr. L. A. Fraikin, Managing Director of Franki, contributed useful ideas for the execution of the work. Mr. H. Jomini was Alcan's resident engineer in Kitimat.

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DEVELOPMENT OF WATER RESOURCES *(Continued from page 49)*

are pending, and preliminary engineering work is being done. These include both small and large works. Water supplies will be pumped considerable distances. Sources of water supply, both surface and underground, will be developed wherever they are considered most advantageous. Sewage treatment will be provided to suit the local needs, and trunk sewers will be constructed to treatment plant sites or to outlets. Municipal boundaries are not to be regarded as the basis for the treatment of sewage, but rather this is considered to be an area problem, so that regardless of the municipality in which the area is situated it may be combined with the adjacent area to advantage and to economy to all concerned.

The boundary waters between Ontario and the United States offer a challenge in the effective control of pollution. These waters with unsurpassed international value must possess high quality to serve their many functions. The International Joint Commission has made surveys and has maintained close contact with conditions. Enforcement of quality standards set by the International Joint Commission has been carried out on the Canadian side by the Ontario Water Resources Commission. This is a co-operative effort designed to reach the desired objective of good stream sanitation.

Good progress is being made on pollution abatement in the boundary waters. The OWRC is participating in the building of municipal plants, and is co-operating closely with industry in their waste treatment problems. Joint efforts can be most effective, and in the boundary waters there is every expectation that the desired results will be a reality in the near future.

Summary

A review of the program of the Ontario Water Resources Commission at this time emphasizes the significance of the original objective to facilitate the development of water supplies and sewage disposal for all municipalities whether they be inland or on large bodies of water. The Province has adopted a program for the development and conservation of water resources and for pollution abatement with full protection of all watercourses in the Province. This pertains to municipalities and industries. A great deal of effort is being devoted to surveys of all water sources, and for determination of discharges to watercourses. Special efforts are being directed to the control of drainage outfalls in small municipalities as well as large ones. In this way, it is hoped to be able to clear all streams of pollution. This is a further step in a program aimed at close co-operation between the Province and the municipalities. The results obtained to date have been most gratifying in spite of the heavy expenditures required for these works. It is not possible to predict with accuracy, the length of time needed to deal with these major programs and especially all sources of pollution now reaching the streams, but the work is proceeding at a rapid pace. There has been splendid co-operation from municipalities and from industry.

Modern methods of water purification are employed, and the degree of treatment of sewage and industrial waste is aimed at the protection required for the watercourse. Naturally this will vary according to local conditions. The trend, however, is definitely towards more complete treatment and for raising the standard of stream sanitation throughout the Province. As the treatment works come into operation, rigid control will be exercised by the Commission to prevent the discharge of untreated or inadequately treated wastes or further pollution of any stream. In this objective, it is felt that the population growth can go forward, and industry can expand while at the same time streams can be utilized fully for disposal of these effluents without undue impairment of their quality or their usefulness. Co-operation of all concerned, which is the basis of this program, cannot fail to achieve the desired results.

BACKWATER COMPUTATIONS FOR THE ST. LAWRENCE POWER PROJECT

Part A — Hydraulic Engineering Aspects of Computations

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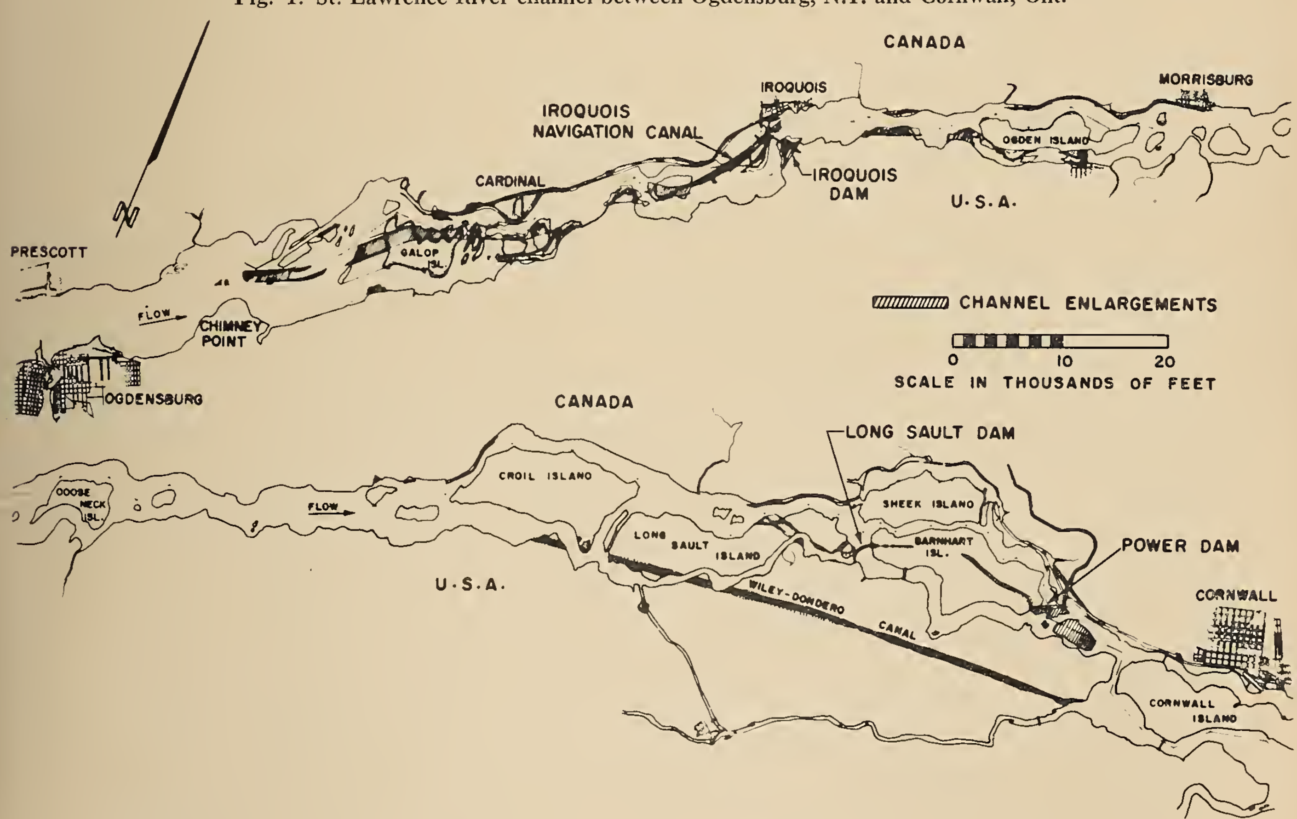
Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June, 1959.

Introduction

EARLY in 1952 the decision was made to begin preparing preliminary designs for construction of the St. Lawrence Power Project. From the hydraulic standpoint it was necessary to determine the operating head on the turbine in the power dam, as well as to establish the size of the water passages in the power dam and other control structures. Designs also were required for channel enlargements, and for the rehabilitation of the flooded headpond area. As a consequence, it became necessary immediately to know the range of water levels which eventually would be experienced under operation in the headpond reservoir, to serve as a basis of hydraulic design.

At the same time it appeared that construction of the 27-ft. Seaway between Montreal and Lake Ontario was imminent. Since the headpond of the Power Project would form part of this navigation system, the range of water levels in the headpond was

Fig. 1. St. Lawrence River channel between Ogdensburg, N.Y. and Cornwall, Ont.



required also by the Seaway entities to design the navigation facilities in the headpond area.

On several occasions prior to 1952, studies had been initiated to develop plans for the Power and Seaway projects. Although these plans had not been completely detailed, sufficient progress had been made to indicate the desirability of carrying out channel enlargements in the International Rapids section of the river. These enlargements would remove a considerable part of the natural shelf which controlled the outflow from Lake Ontario. Thus the headpond of the Power project would in effect extend upstream to Lake Ontario, and the water levels in the headpond would depend upon the levels to be maintained on Lake Ontario. As a result, when the need arose in 1952 for a knowledge of the range of water levels in the headpond reservoir, it was decided that backwater computations would be made for this purpose, and that water surface profiles would be prepared for the river reaches extending from the power dam site near Cornwall, Ontario, upstream to Lake Ontario.

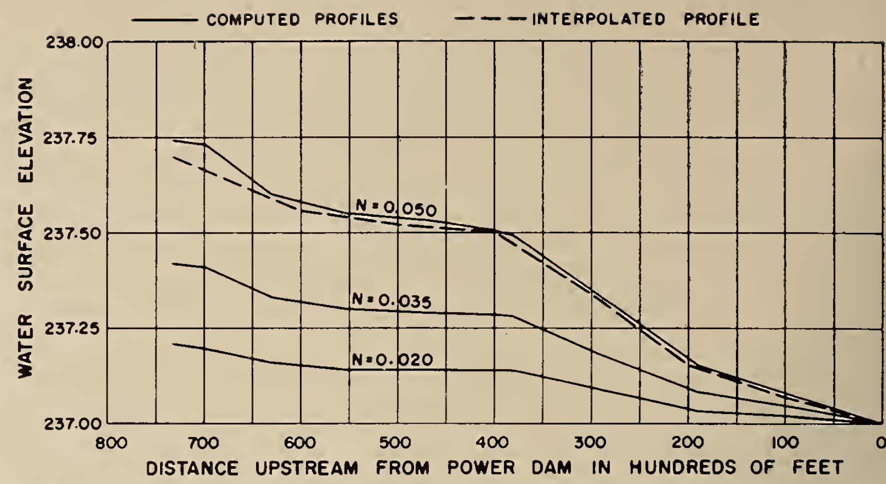
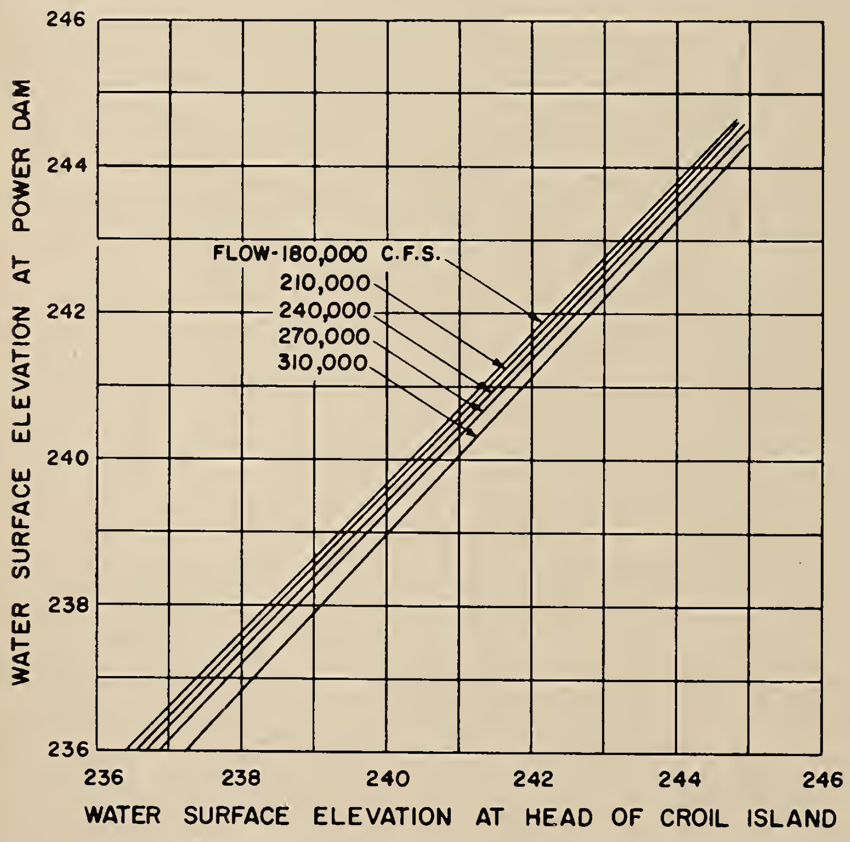


Fig. 2. Computed and interpolated backwater profiles between power dam and head of Croil Island open water condition.

Basic Data

Fundamental requirements for an accurate, comprehensive backwater study include a set of contour maps of the river shores and channel, and stage-discharge relationships at sufficient points along the channel to provide the means for determining the channel roughness. From earlier surveys, a set of maps had been produced, giving subaqueous contours and shore topography between the power dam and Chimney Point. Limited soundings from navigation charts were available for the reaches from Chimney Point to Lake Ontario. However, very few up-to-date water-level records were available to provide channel roughness, and an extensive program of gauging was established immediately on the river to provide the necessary information. Since a considerable period of time would be required to obtain sufficient gauge records to establish the channel roughness, and since it was felt that the backwater computations should not be delayed, it was decided to proceed with the computations using a range of channel roughnesses which, it was hoped, would be sufficiently wide to bracket the values eventually selected.

Fig. 3. Computed backwater slopes-power dam to head of Croil Island open water condition.



Variables Selected

Two general channel conditions were assumed for carrying out backwater computations. In the first, no channel enlargements were assumed, and in the second, enlargements were assumed between the power dam and Chimney Point, which is approximately four miles east of Ogdensburg, N.Y., as shown in Fig. 1. For the most part, these enlargements were taken from reports summarizing earlier studies by the Corps of Engineers, U.S. Army. Additional enlargements in the vicinity of Iroquois were included to correspond with studies made by the Canadian Department of Transport. It was decided also that backwater slopes should be computed assuming open water conditions for the unimproved river channel, and open water and ice cover conditions for the improved river channel.

As indicated earlier, the proposed scheme of channel enlargements would largely eliminate the effects of the natural control section on the outflows from Lake Ontario. As a result, it had been accepted that some method would be adopted to regulate Lake Ontario elevations and outflows. Early in 1952, when the decision was made to proceed with the backwater computations, it appeared that Method No. 5, prepared by the Canadian Department of Transport, might be selected subsequently for this purpose. Under this regulation method, the range of outflows would be from 180,000 c.f.s. to 310,000 c.f.s. and from 180,000 c.f.s. to 260,000 c.f.s. for open water and ice-covered conditions respectively. Consequently, the following discharges were selected for the backwater computations:

Open water conditions
180,000, 240,000 and 310,000 c.f.s.

Ice-cover conditions
180,000, 220,000 and 260,000 c.f.s.

The assumed channel roughness, stated in terms of Manning's "n", were as follows:

Natural river channel
0.020, 0.035 and 0.050

Channel enlargements
0.020 and 0.035

Ice cover 0.025

The composite values of "n" for a channel with ice cover were obtained by averaging the values of "n" for ice cover and for the channel bed on the basis of the proportion of the wetted perimeter. When these discharges and roughnesses were combined with three assumed starting elevations at the power dam for each condition of the two general schemes, a total of 99 backwater cases resulted.

Table I. Areas and Conveyance Factors of River Cross-Sections No Improvements

Open Water Computations

Section	*Elevation 1935 Datum*	*Area Sq. Ft.*	*nK Millions*
0 + 00	235	242,750	5.570
	236	246,750	5.715
	238	254,500	6.010
	240	262,500	6.320
	242	270,300	6.635
	244	278,200	6.960
	246	286,100	7.295
	248	293,750	7.635
	250	301,750	7.980
26 + 00	235	181,700	3.030
	236	185,900	3.135
	238	194,500	3.358
	240	202,800	3.580
	242	211,500	3.840
	244	220,800	4.125
	246	230,500	4.435
	248	240,250	4.755
	250	250,300	5.090
50 + 00	235	215,250	3.575
	236	221,600	3.715
	238	234,000	4.020
	240	246,000	4.350
	242	257,700	4.710
	244	269,300	5.075
	246	281,000	5.450
	248	292,750	5.835
	250	304,700	6.235

Methods Used

In the pre-project state, there was a difference of approximately 85 ft. at mean discharge between the water levels at Lake Ontario and at the site of the power dam near Cornwall. All but about one ft. of this fall was concentrated in the reaches between the power dam and Chimney Point. With the Power project in operation, the flooding from the forebay would extend upstream approximately to Chimney Point, but in the channel between Chimney Point and Lake Ontario, stages would remain substantially unaltered.

Table II. Areas and Conveyance Factors of River Cross-Sections Improved Channel

Open Water Computations

			Conveyance Factor K (millions)			
Section	*Elevation 1935 Datum*	*Area Sq. Ft.*	$n = 0.050$ $i = 0.035$	$n = 0.035$ $i = 0.035$	$n = 0.035$ $i = 0.020$	$n = 0.020$ $i = 0.020$
0 + 00	235	242,750	111.40	159.13	159.13	278.50
	236	246,750	114.30	163.28	163.28	285.75
	238	254,500	120.20	171.71	171.71	300.50
	240	262,500	126.40	180.56	180.56	316.00
	242	270,300	132.70	189.56	189.56	331.75
	244	278,200	139.20	198.85	198.85	348.00
	246	286,100	145.90	208.42	208.42	364.75
	248	293,750	152.70	218.13	218.13	381.75
	250	301,750	159.60	228.00	228.00	399.00
26 + 00	235	181,700	60.60	86.57	86.57	151.50
	236	185,900	62.70	89.57	89.57	156.75
	238	194,500	67.16	95.94	95.94	167.90
	240	202,800	71.60	102.28	102.28	179.00
	242	211,500	76.80	109.71	109.71	192.00
	244	220,800	82.50	117.85	117.85	206.25
	246	230,500	88.70	126.71	126.71	221.75
	248	240,250	95.10	135.85	135.85	237.75
	250	250,300	101.80	145.42	145.42	254.50
50 + 00	235	215,250	71.50	102.14	102.14	178.75
	236	221,600	74.30	106.14	106.14	185.75
	238	234,000	80.40	114.85	114.85	201.00
	240	246,000	87.00	124.28	124.28	217.50
	242	257,700	94.20	134.56	134.56	235.50
	244	269,300	101.50	145.00	145.00	253.75
	246	281,000	109.00	155.71	155.71	272.50
	248	292,750	116.70	166.71	166.71	291.75
	250	304,700	124.70	178.13	178.13	311.75

n = Roughness of natural portion of channel
i = Roughness of improved portion of channel

Between the power dam and Chimney Point, where the greatest change in water levels would be effected, it was decided to perform the backwater computations by means of the standard-step method, using an adaptation of the Chezy-Manning equation proposed by Leach[1]. This method provides a convenient solution for problems dealing with channel cross-sections having a submerged flood plain, or other irregular conditions such as an artificial enlargement in part of the section, which necessitates separate computations. The discharge in open channels by the Chezy-Manning formula is:

$$Q = \frac{1.486}{n} AR^{2/3} S^{1/2}$$

or, putting $K_d = \dfrac{1.486}{n} AR^{2/3}$

$$Q = K_d S^{1/2}$$

For a constant "n", K_d varies only with the stage. Thus at a channel cross-section where the flow must be subdivided, K_d is obtained for each sub-section using the area, hydraulic radius and roughness applying to the sub-section. The sum of these values of K_d is the value of K_d applying to the entire cross-section. Hence at any cross-section, the slope of the hydraulic gradient is given by the equation

$$S = \frac{(Q)^2}{(K_d)^2}$$

by averaging the slopes at two ends of a reach, the friction loss in the reach is found by multiplying its length by the mean of the slopes.

In addition to friction losses, bend and expansion losses were included where applicable. Bend losses were computed when the total bend angle was greater than 45°, and expansion losses when the velocity at the upstream end of a reach exceeded the velocity at the downstream end. The equations used for these minor losses were as follows:

$$\text{Bend Loss} = \frac{1}{2} K_b \left(\frac{V_1^2}{2g} + \frac{V_2^2}{2g}\right)$$

$$\text{Expansion Loss} = \frac{1}{2} \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$$

where:—V_1 and V_2 are the velocities in feet per second at the downstream and upstream ends of the reaches, respectively.

—K_b is a coefficient depending on the bend angle.

For want of better information on open channel bend losses, the results of model tests on pipe bends were used. Based on these tests the following bend loss coefficients were selected:

Bend Angle in Degrees	*Bend Loss Coefficients K_b*
45	0.18
60	0.22
75	0.26
90	0.29
105	0.31

The length of the main river channel between the power dam and Chimney Point is slightly more than 40 miles. In about 4/5 of this distance, large islands divide the river channel, and in about 2/3 of the distance, groups of islands form complicated channel networks. Because of the length and complexity of the river channel, and since backwater profiles were urgently required for 99 cases, it was decided to carry out the computations by means of a Ferranti digital computer at the University of Toronto Computation Centre.

Between Chimney Point and Lake Ontario, where stages during operation of the Power project would be practically unchanged from pre-project conditions, backwater slopes would be obtained by means of the unit fall - discharge method using recorded pre-project elevations and flows.

Preparation of Data

Using the contour maps of the river between the power dam and Chimney Point, approximately 230 channel cross-sections were selected. For each of these sections, the areas and conveyance factors were computed as a function of the water surface elevation. For the ice cover condition, an ice thickness of one foot was assumed, with the water surface coinciding with the top of the ice sheet.

In the case of the open water unimproved channel, the conveyance factor was left in the form nK_d

(where $nK_d = 1.486AR^{2/3}$)

Since the same value of "n" would apply at all cross-sections for each open water unimproved backwater case, only one set of conveyance factors was prepared in the above form. When the backwater computations were being performed on the Ferranti computer, one of the necessary operations was the division of the quantity "nK" by the appropriate value of "n". However, when channel enlargement and/or ice cover were included, it was found desirable to compute values of K_d manually for the various assumed combinations of "n". Sample tabulations of these data supplied to the Computation Centre are shown in Tables I, II and III.

The inclusion of channel enlargements was found to have an appreciable effect on the reach lengths and bend loss coefficients. Hence two sets of these data were required, as shown in Tables IV and V.

Selection of Actual Channel Roughnesses

While water surface profiles for the 99 backwater cases were being determined at the Computation Centre,

Table III. Areas and Conveyance Factors of River Cross-Sections Improved Channel

Ice Cover Computations

Section	Elevation 1935 Datum	Area Sq. Ft.	Conveyance Factor K (millions) $n = 0.035$ $i = 0.0275$	$n = 0.0275$ $i = 0.0275$	$n = 0.0275$ $i = 0.020$	$n = 0.020$ $i = 0.020$
0 + 00	233	230,600	93.03	118.40	118.40	162.80
	234	234,500	95.46	121.49	121.49	167.05
	236	242,500	100.80	128.29	128.29	176.40
	238	250,500	106.26	135.24	135.24	185.95
	240	258.250	111.66	142.11	142.11	195.40
	242	266,000	117.37	149.38	149.38	205.40
	244	274,000	123.20	156.80	156.80	215.60
	246	281.800	129.14	164.36	164.36	226.00
	248	289,750	135.23	172.11	172.11	236.65
	250	297,600	141.37	179.93	179.93	247.40
26 + 00	233	166,800	48.71	62.00	62.00	85.25
	234	171.100	50.42	64.18	64.18	88.25
	236	179,800	54.14	68.91	68.91	94.75
	238	188,500	58.06	73.89	73.89	101.60
	240	197,600	62.29	79.27	79.27	109.00
	242	207,000	66.86	85.09	85.09	117.00
	244	216,600	72.00	91.64	91.64	126.00
	246	226,000	77.49	98.62	98.62	135.60
	248	235,600	83.37	106.11	106.11	145.90
	250	245,500	89.14	113.45	113.45	156.00
50 + 00	233	197,300	56.63	72.07	72.07	99.10
	234	203,500	59.06	75.16	75.16	103.35
	236	216,000	64.11	81.60	81.60	112.20
	238	228,000	69.63	88.62	88.62	121.85
	240	240,000	75.49	96.07	96.07	132.10
	242	251.700	81.83	104.15	104.15	143.20
	244	263,500	88.37	112.47	112.47	154.65
	246	275,100	95.20	121.16	121.16	166.60
	248	287,000	102.17	130.11	130.11	178.90
	250	298,750	109.14	138.91	138.91	191.00

n = Roughness of natural portion of channel
i = Roughness of improved portion of channel

data from the gauging programme on the river were being processed. Stage-discharge relationships at the newly-selected gauge locations were determined by relating the water surface elevations at these points with those at long-term gauge installations having established stage-discharge relationships. Distribution of the total river discharge around islands was determined from flow measurements obtained by current meters. Using recorded water levels and the corresponding discharges, backwater effects between several gauges were calculated to determine the channel roughness which would produce the observed slope. These computations were made for channels carrying the full river flow, and also for divided channels formed by islands. Bend and expansion losses were calculated and deducted so that the true channel roughness could be established as nearly as possible.

Since these calculations were based on pre-project water levels, and since the final backwater slopes were required for the flooded reservoir, the computed roughnesses were modified[2] to apply to the channel when water levels were raised. The values of Manning's "n" finally selected for the flooded channels were as follows:

Table IV. Reach Lengths and Bend Loss Coefficients
No Improvements

Section	*Length of Reach (Ft.)*	*Bend Loss Coefficient*	*Remarks*
1156 + 00			
	1,200	0.18	
12 + 00 MU			
	2,000	0.22	
32 + 00 MU			
	2,600	0.11	
58 + 00 MU			
	1,500	0.10	
1215 + 00			
1215 + 00			
	1,600	0	
1231 + 00			Common Stations at Lower End of Split Channels
	1,600	0	
1247 + 00 CA			
	700	0	
1254 + 00 CA			
	800	0	
1262 + 00 CA			
	1,600	0	
1278 + 00 OG			Junction
	1,400	0	
1292 + 00 OG			
	1,800	0	
1310 + 00 OG			
	2,000	0	
1330 + 00 OG			
	2,000	0.18	
1350 + 00 OG			
	2,000	0	
1370 + 00 OG			
	2,000	0	
1390 + 00 OG			
	2,000	0	
1410 + 00 OG			
	2,100	0	
1431 + 00 OG			
	1,200	0	
1443 + 00			Common Station at Upper End of Split Channels

	Open Water Conditions	*Channels with Ice Cover*
Natural Channel		
Channels without islands	0.032	0.0285
Split channels formed by islands	0.044	0.0345
Channel Enlargements	0.025	0.025

In the foregoing tabulation, the values of "n" for channels with ice cover assumed a roughness of 0.025 for the ice sheet. This value was based on operating experience in the canals supplying water to the Beauharnois plant of the Quebec Hydro-Electric Commission, and to Ontario Hydro's Sir Adam Beck-Niagara Generating Station No. 1.

The roughness values selected for the natural channels were the average of two groups each containing several modified values of "n" based on pre-project water levels and discharge. It is, perhaps, worthy of note that the individual values of "n" comprising each group showed a remarkable consistency.

Interpolation of Computations

When the flooded channel roughnesses had been decided, it was necessary to interpolate the profiles produced by the Computation Centre, for which the previously chosen ranges of roughness had been used. The following equations were developed:

(a) In a reach consisting of cross-sections having a single value of "n" for each backwater profile, the friction loss for the desired value of "n" was given by the equation:

$$hf_2 = \left(\frac{2n_2}{(n_1/hf_1^{1/2}) + (n_3/hf_3^{1/2})}\right)^2 \quad \text{(a)}$$

where hf_1 and hf_3 are computed friction losses for assumed roughnesses of n_1 and n_3 respectively.
n_2 is the selected roughness for which friction loss hf_2 is required.
n_1 and n_3 bracket n_2.

(b) When cross-sections in a reach include channel enlargements, and separate values of "n" were assigned to the natural and improved portion, the friction losses for the desired "n" values were given by the equation:

$$\frac{1}{(hfn_3/i_3)^{1/2}} = \left(\frac{(1/n_3) - (1/n_2)}{(1/n_1) - (1/n_2)}\right)\frac{1}{(hfn_1/i_1)^{1/2}} + \left(\frac{(1/i_1) - (1/i_3)}{(1/i_1) - (1/i_2)}\right)\frac{1}{(hfn_2/i_2)^{1/2}} + \left(\frac{(1/n_1) - (1/n_3)}{(1/n_1) - (1/n_2)} + \frac{(1/i_3) - (1/i_2)}{(1/i_1) - (1/i_2)} - 1\right)\frac{1}{(hfn_2/i_1)^{1/2}} \quad \text{....(b)}$$

where hfn_3/i_3 is the required friction loss in a reach in which the natural and improved roughnesses are n_3 and i_3 respectively.
hfn_1/i_1, hfn_2/i_1 and hfn_2/i_2 are known friction losses, computed using the indicated natural and improved roughness combinations.

To obtain the interpolated backwater slopes, the channel between the power dam and Chimney Point was divided into 22 reaches averaging about 10,000 ft. in length. Losses in these reaches were taken from the backwater slopes computed by the Ferranti computer, and were modified by applying the above equations to obtain slopes for the values of "n" established from studies based on recorded water levels. Computed backwater profiles and the resulting interpolated profile for a typical reach are given in Fig. 2.

It was realized that interpolation by the above equations would be strictly accurate only if applied to pure friction losses in the reach. The actual losses included not only friction losses, but also bend and expansion losses which would be independent of the friction loss. Thus the interpolation process introduced a possible source of error, since bend and expansion losses were modified as well as friction losses. However, no practical method of separating these losses was evident and since these minor losses represented a small percentage of the total, it was decided to interpolate the total loss and to make several check computations to determine whether a serious error resulted.

Checks on Machine Accuracy and Interpolation Methods

To ensure that the calculations by the Ferranti computer were accurate and that the interpolation methods were reasonably correct, the following manual computations were made:

(a) Solution of the Goose Neck Island networks
(b) Solution of the Galop Island network
(c) Computation in South Galop channel
(d), (e) and (f) Solution of the Galop Island network for flows of 310,000 c.f.s., 240,000 c.f.s. and 180,000 c.f.s.
(h)-(k) incl. Computations in the vicinity of the Iroquois Dam, with and without ice cover.

Of the above checks, (a), (b) and (c) were made to determine the accuracy of the machine in solving networks and in computing losses in a channel. In each of these checks, the same values of "n" was used in the manual check as in the machine computation so that the results were directly comparable. Checks (d)-(k) were for verification of the interpolated results, and in each case the value of "n" used was the one for which the interpolated curves were obtained. It was found that the machine and manual computations agreed very closely, but that the interpolated profiles indicated slightly higher losses than the manual computations. Since the maximum discrepancy occurred at a discharge of 240,000 c.f.s. it was decided to compute a complete profile at that discharge. This computed profile was practically identical with the interpolated profile between the power dam and Morrisburg. Between Morrisburg and Chimney Point, the profiles diverged, with the interpolated profile being 0.24 ft. higher at Chimney Point. Since this cumulative difference occurred in a distance of approximately 18 miles, it was considered that the interpolation methods gave results which were reasonably free from error. Furthermore, it was realized that hydraulic models would be constructed to investigate the design of channel enlargements in the reaches between Morrisburg and Chimney Point, and that these models would be used to verify the backwater slopes.

Table V. Reach Lengths and Bend Loss Coefficients Improved Channel

Section	*Length of Reach (Ft.)*	*Bend Loss Coefficient*	*Remarks*
1156 + 00			
	1,200	0.18	
12 + 00 MU			
	2,000	0.22	
32 + 00 MU			
	2,600	0.11	
58 + 00 MU			
	1,500	0.10	
1215 + 00			
1215 + 00			
	1,600	0	
1231 + 00			Common Station at Lower End of Split Channels
	1,600	0	
1247 + 00 CA			
	700	0	
1254 + 00 CA			
	800	0	
1262 + 00 CA			
	1,600	0	
1278 + 00 OG			Junction
	1,400	0	
1292 + 00 OG			
	1,800	0	
1310 + 00 OG			
	2,500	0.08	
1335 + 00 OG			
	1,800	0.06	
1353 + 00 OG			
	1,600	0.05	
1369 + 00 OG			
	2,000	0	
1389 + 00 OG			
	2,000	0	
1409 + 00 OG			
	2,000	0	
1429 + 00 OG			
	1,200	0	
1441 + 00			Common Station at Upper End of Split Channels

Preparation of Final Backwater Curves

Although water surface profiles were computed and interpolated for the channels with and without enlargements, final backwater curves were prepared only for the channels with enlargements. To isolate and permit detailed studies of various groups of channel enlargements, the river channel between the power dam and Chimney Point was divided into six reaches. From cross-plots of the interpolated backwater profiles, slopes for open water and for ice cover were obtained for each of these reaches. The open water losses between Lake Ontario and Chimney Point were derived from a unit fall-discharge curve based on pre-project water levels for summer months. Ice cover losses in this reach were assumed to be 0.25 foot higher than for open water as indicated by comparing gauge-relation curves for summer and winter months. Overall losses between Lake Ontario and the power dam were derived by including losses through the Iroquois Dam as computed by the Canadian Department of Transport. Drawings then were prepared to show the water level at the head and foot of the reaches as a function of the river discharge. Curves for a typical reach are given in Fig. 3.

Uses of Backwater Curves

The design and construction of the St. Lawrence Power Project was a joint venture undertaken by the Power Authority of the State of New York, and Ontario Hydro. The hydraulic design of the project was allotted to Ontario Hydro, and as a result, the engineering staff of that organization has used the backwater

(Continued on page 66)

BACKWATER COMPUTATIONS FOR THE ST. LAWRENCE POWER PROJECT

Part B. Backwater Calculations on the Ferranti Digital Computer.

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Presented at the 73rd Annual General and Professional Meeting of The Enginering Institute of Canada, Toronto, Ont., June 1959.

Formulation of Basic Reach Equation

IN BACKWATER calculations as described in part A of this paper by H. M. McFarlane, certain parameters of a river are assigned, e.g. its course (including branches), the profile of its bed, roughness of channels, discharge of water, etc., and the problem is to compute the water elevations along its course for these conditions. The basic equation assumes steady state flow and relates the water levels at two stations (i.e. the two ends) of a reach (i.e. a channel of uniform cross-section, A).

Let E_1 be the energy per unit mass of the water at station 1,

E_2 be the energy per unit mass of the water at station 2,

assumed to be upstream from station 1. Then $E_2 = E_1 +$ energy loss between 1 and 2.

Now $E_1 = gW_1 + \frac{1}{2}v_1^2$

where W_1, v_1 are water level and velocity at station 1, this velocity being taken as uniform over the whole cross-section, and $E_2 = gW_2 + \frac{1}{2}v_2^2$

therefore $gW_2 + \frac{1}{2}v_2^2 = gW_1 + \frac{1}{2}v_1^2 +$ energy loss between 1 and 2.

If we write $(v^2/2g) = hv$, the velocity head and let $(1/g) \times$ (energy loss between 1 and 2) $= hf_{1,2} + hb_{1,2} + ht_{1,2}$ where ghf is the energy loss due to friction, ghb is the energy loss due to change in alignment or bending and ght is the energy loss due to expansion or turbulence, then

$$W_2 = W_1 + hv_1 - hv_2 + hf_{1,2} + hb_{1,2} + ht_{1,2} \quad \ldots(1)$$

The expressions for the head losses due to friction, bending and turbulence are found from empirical equations. They are :

$$hb_{1,2} = \frac{B}{2}(hv_2 + hv_1) \quad \ldots(2)$$

where B is a head loss coefficient which is tabulated as a function of the total deflection of a given bend, and is found to vary between 0 and 0.34,

$$ht_{1,2} = \text{const.}\,(hv_2 - hv_1) \text{ when } hv_2 > hv_1 \quad \ldots(3)$$
$$= 0 \text{ when } hv_2 \leq hv_1$$

and for the work reported here the constant has been taken as 0.5,

$$hf_{1,2} = \frac{L}{2}\left(\frac{Q_1^2}{K_1^2} + \frac{Q_2^2}{K_2^2}\right) \quad \ldots(4)$$

where L is the reach length, Q is the discharge, and

and $$K = \frac{1.486}{n} AR^{2/3}$$

A = cross sectional area,
n = a roughness coefficient, known for the type of channel,
R = hydraulic radius $= A/(b + d)$,
b = river surface width
d = mean depth $= A/b$.

Noting that $Q = vA$ equation (1) becomes

Three Island Network

Fig. 1. Plan

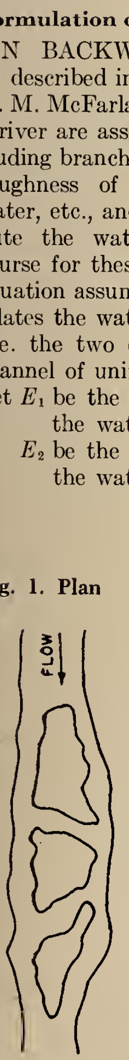
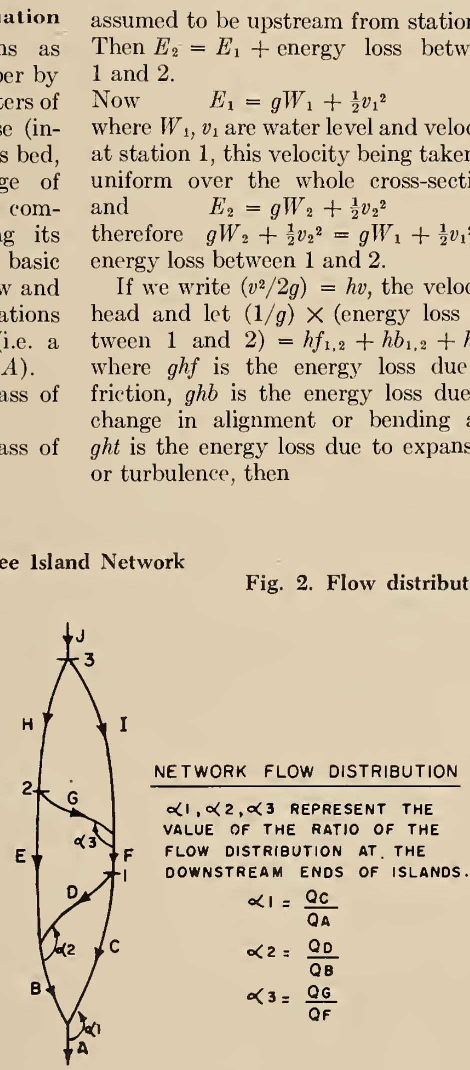


Fig. 2. Flow distribution



$$W_2 = W_1 + \frac{Q_1^2}{2gA_1^2} - \frac{Q_2^2}{2gA_2^2} + \frac{L}{2}\left(\frac{Q_1^2}{K_1^2} + \frac{Q_2^2}{K_2^2}\right) + \frac{B}{2}\left(\frac{Q_2^2}{2gA_2^2} + \frac{Q_1^2}{2gA_1^2}\right) + \delta\left(\frac{Q_2^2}{2gA_2^2} - \frac{Q_1^2}{2gA_1^2}\right)$$

where $\delta = 0$ if $hv_2 \leq hv_1$ and $\delta = \frac{1}{2}$ if $hv_2 > hv_1$ or

$$W_2 = W_1 + \frac{Q_1^2}{2gA_1^2}\left(\frac{gLA_1^2}{K_1^2} + \frac{B}{2} + \Gamma\right) + \frac{Q_2^2}{4gA_1^2}\left(\frac{gLA_2^2}{K_2^2} + \frac{B}{2} - \Gamma\right) \quad \ldots.(5)$$

with $\Gamma = 1 - \delta$.

Equation (5) is used to calculate W_2 from W_1. Since A and K depend on W_2 it is convenient to set up an iteration whereby $W_2{}^n$, defined as W_2 at iteration n, is assumed to be known and is used to determine the quantities appearing in the R. H. S. of (5) from which $W_2{}^{n+1}$ is found. This is continued as long as necessary, producing $W_2{}^{n+2}$, $W_2{}^{n+3}\ldots$ until convergence is reached. In practice only two or three iterations are required. The process is started by taking $W_2{}^0 = W_1$, at the end of the reach, i.e. by assuming that there is no change in level across the reach. An iteration of this kind is very well suited to an electronic computer which was used to carry out the calculation.

Island Nets

The calculations become considerably more complicated when there are islands in the river, causing the flow to divide. In discussing this, it is convenient to introduce a number of terms as follows:

Link—a reach or series of reaches having a common discharge or a single reach having different discharges at its ends;

Branch—a sequence of links having consecutive station numbers;

Net—the region including one or more islands between the two closest stations having full river discharge;

Section—a larger unit which may include several branches or nets but which must terminate with stations having full river discharge.

The method which was developed for handling nets will be illustrated by means of the example shown in Fig. 1 where there are three islands. The link representation of this net is shown in Fig. 2. If the correct flow were known for each branch then the calculation of the water levels could proceed by the straightforward application of equation (5). However, the flows are not known and therefore we introduce three parameters:

$\alpha_1 = (Q_C/Q_A)$ where Q_C = flow in branch C

Q_A = flow in reach A = total discharge and similarly

$$\alpha_2 = \frac{Q_D}{Q_B} \quad \text{and} \quad \alpha_3 = \frac{Q_G}{Q_F}$$

The flow in each branch is easily found in terms of these parameters and Q_A.

For example

$$Q_E = Q_A(1 - \alpha_1)(1 - \alpha_2)$$

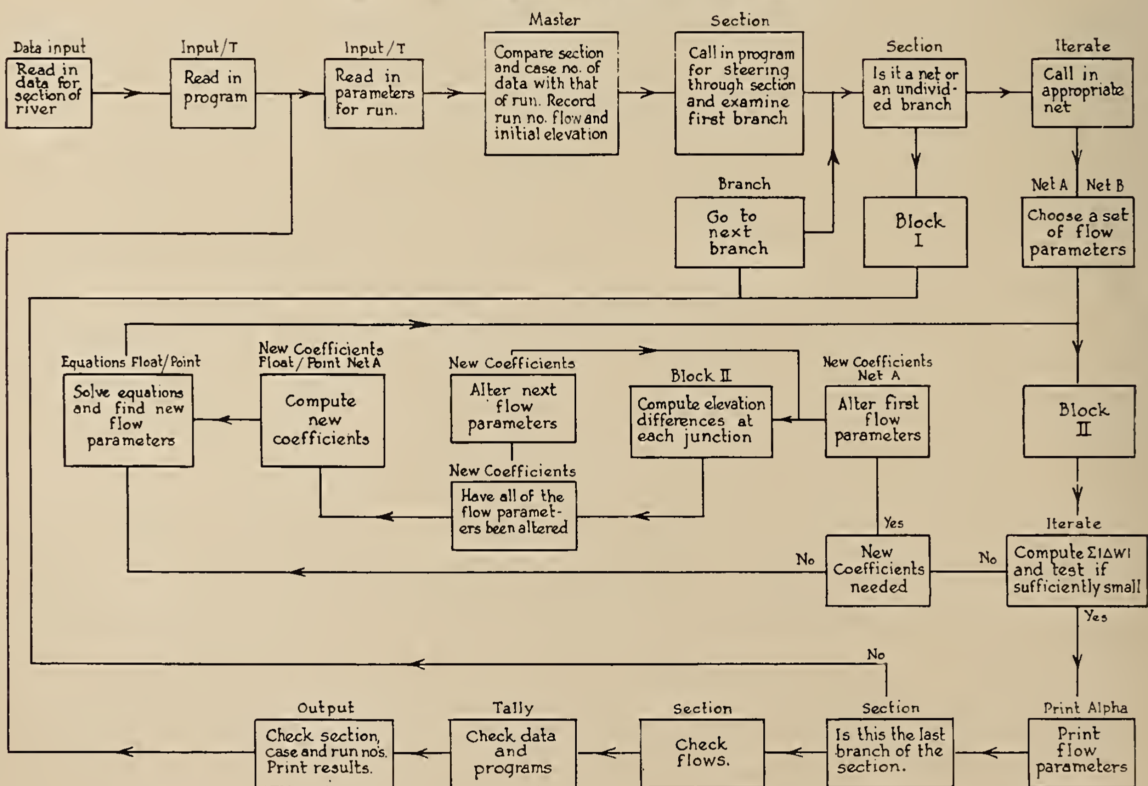
and $Q_G = Q_A\alpha_3(\alpha_1 + \alpha_2 - \alpha_1\alpha_2)$

If arbitrary values of α_1, α_2 and α_3 are chosen then the conditions of flow will not be satisfied as will be seen from the fact that W_1, the water-level at the junction of branches B, C, D, will be different as found by going up the branch C, than that found by going up the branches D and B. Similarly at confluences 2 and 3 (Fig. 2), the other places where branching parameters were not defined, the water levels W_2 and W_3 will depend on the route taken to reach the junction. The problem then, is to choose α_1, α_2 and α_3 so that

W_1 via link C − W_1 via links B, D = 0

W_2 via links B, E − W_2 via links $C, F, G,$ = 0

Fig. 3. Flow diagram for backwater calculations



W_3 via links $B, E - W$ via links $C, F, I, = 0$ ....(6)

Let $\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3$ be the true values which will satisfy the equations (6) and let $\alpha_1, \alpha_2, \alpha_3$ be approximate solutions. When $\alpha_1, \alpha_2, \alpha_3$ are substituted into the L.H.S. of the equations we will get not zero but ΔW_1, ΔW_2, and ΔW_3 and we may write:

$$\Delta W_1 = f_1(\alpha_1, \alpha_2, \alpha_3)$$
$$\Delta W_2 = f_2(\alpha_1, \alpha_2, \alpha_3)$$
$$\Delta W_3 = f_3(\alpha_1, \alpha_2, \alpha_3)$$

The functions f_1, f_2, f_3 may be expanded in Taylor's series about the point $\alpha_1, \alpha_2, \alpha_3$, and ignoring derivatives higher than the first we have:

$$\Delta W_1 = f_1(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) + (\alpha_1 - \bar{\alpha}_1)\left(\frac{\partial f_1}{\partial \alpha_1}\right)_0 + (\alpha_2 - \bar{\alpha}_2)\left(\frac{\partial f_1}{\partial \alpha_2}\right)_0 + (\alpha_3 - \bar{\alpha}_3)\left(\frac{\partial f_1}{\partial \alpha_3}\right)_0 + \ldots$$

$$\Delta W_2 = f_2(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) + (\alpha_1 - \bar{\alpha}_1)\left(\frac{\partial f_2}{\partial \alpha_1}\right)_0 + (\alpha_2 - \bar{\alpha}_2)\left(\frac{\partial f_2}{\partial \alpha_2}\right)_0 + (\alpha_3 - \bar{\alpha}_3)\left(\frac{\partial f_2}{\partial \alpha_3}\right)_0 + \ldots$$

$$\Delta W_3 = f_3(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) + (\alpha_1 - \bar{\alpha}_1)\left(\frac{\partial f_3}{\partial \alpha_1}\right)_0 + (\alpha_2 - \bar{\alpha}_2)\left(\frac{\partial f_3}{\partial \alpha_2}\right)_0 + (\alpha_3 - \bar{\alpha}_3)\left(\frac{\partial f_3}{\partial \alpha_3}\right)_0 + \ldots \quad \ldots(7)$$

where the subscript 0 indicates that the partial derivatives are to be evaluated at the points $\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3$. We also note that

$$f_1(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) = f_2(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) = f_3(\bar{\alpha}_1, \bar{\alpha}_2, \bar{\alpha}_3) = 0.$$

For a given set of approximate values $\alpha_1, \alpha_2, \alpha_3$ the left hand sides of equation (7), $\Delta W_1, \Delta W_2, \Delta W_3$ can be calculated by applying the basic reach equation along each branch, and if the values of the partial derivatives were known it would then be possible to solve for $\bar{\alpha}_1 - \alpha_1, \bar{\alpha}_2 - \alpha_2$ and $\bar{\alpha}_3 - \alpha_3$, i.e. the corrections to the α's which will make the solution better. These partial derivatives can be found numerically by introducing slight changes in the α's and noting the corresponding changes in the ΔW's. Thus suppose a slight displacement k, is introduced systematically into the α's, and the W's found according to the following table.

Branching Parameters			*Corresponding level differences* W_1	W_2	W_3
α_1	α_2	α_3	$\Delta W_{0,1}$	$\Delta W_{0,2}$	$\Delta W_{0,3}$
$\alpha_1 + k$	α_2	α_3	$\Delta W_{1,1}$	$\Delta W_{1,2}$	$\Delta W_{1,3}$
$\alpha_1 + k$	$\alpha_2 + k$	α_3	$\Delta W_{2,1}$	$\Delta W_{2,2}$	$\Delta W_{2,3}$
$\alpha_1 + k$	$\alpha_2 + k$	$\alpha_3 + k$	$\Delta W_{3,1}$	$\Delta W_{3,2}$	$\Delta W_{3,3}$

Then we have at once that:

$$\frac{\partial W_1}{\partial \alpha_1} = \frac{\Delta W_{11} - \Delta W_{01}}{k}, \quad \frac{\partial W_2}{\partial \alpha_1} = \frac{\Delta W_{12} - \Delta W_{02}}{k}, \quad \frac{\partial W_3}{\partial \alpha_1} = \frac{\Delta W_{13} - \Delta W_{03}}{k}$$

and similarly for the other derivatives.

It should be noted that these derivatives have been found in the neighbourhood of the approximate solution rather than the neighbourhood of the true solutions where they are required. The corrections to the α's can then be found by solving the set of linear equations (7), and the results used as the beginning of a new iteration. It is not always necessary to redetermine the partial derivatives for later cycles. The sum of the absolute values of the errors ΔW can be used as a criterion for stopping the iteration.

There is no guarantee that the iteration used to solve for the flows will always converge, but in practice it was found that convergence was reached in a few cycles except in one circumstance. Suppose it turns out that the flow in a cross channel such as G in Fig. 2 is very small. On the next cycle it could happen that the flow in G would be reversed, and on still another cycle the flow might come back to the original direction. Such oscillatory solutions did in fact arise on the computer but it was possible to recognize their occurrence and take care of this case by setting the flow in G to be zero (taking $\alpha_3 = 0$) which is equivalent to setting up a wall in channel G.

The Computer Program

After some preliminary trials using desk calculation, an analog machine and conventional punched card equipment, the back-water computations were put on *Ferut**, the Ferranti electronic digital computer which had just been installed at the University of Toronto. *Ferut* has been described elsewhere[1] and therefore only its vital statistics will be given here. It is a serial binary computer, having two levels of store, one electrostatic with 512, 40 bit words, the other a magnetic drum with 256, 64 word tracks. The machine has 7 B registers, a versatile instruction code and addition and multiplication times of about 1 and 2 ms., respectively. At the time of installation input was by means of a photo-electric paper tape reader (200 characters/sec) and output could be punched on tape (18 characters/sec) or printed on an electric typewriter (12 characters/sec). A great deal of special preparation has to be done before a large problem can be run on a computer and this work for the back-water problem will now be described briefly.

Scaling

A machine such as *Ferut* regards all numbers as if they had a fixed decimal point e.g. on the extreme left in which case numbers are all fractions in the range $+\frac{1}{2}$ to $-\frac{1}{2}$, or on the extreme right in which case numbers are regarded as integers. This means that constants, parameters and variables have to be adjusted by scale factors which ensure that numbers always re-

*FERUT was operated at the University of Toronto from June 1952 to May 1958, after which it was moved to the Division of Mechanical Engineering, National Research Council where it is at present operating.

$$W = 2^{-21}W \qquad \beta = \tfrac{1}{2}$$
$$q = 2^{-40}Q^2/4g \qquad \gamma = 10^{-4}\Gamma = 10^{-4} \text{ if } x_2q_2 \le x_1q_1$$
$$\lambda = 10^{-4}L \qquad = \tfrac{1}{2} \times 10^{-4} \text{ if } x_2q_2 > x_1q_1$$
$$x = 10^4/A^2$$
$$y = (10A/K)^2 \qquad \bar{g} = g/100$$

With these substitutions, the working form of equation (5) becomes:

$$w_2 = w_1 + 2^{20}q_1x_1(\bar{g}\lambda y_1 + \beta + \gamma) + 2^{20}q_2x_2(\bar{g}\lambda y_2 + \beta - \gamma) \quad \ldots(8)$$

main within the proper bounds. The scaling for the quantities of the previous two sections is shown in equation (8) :

Routines

A computer calculation is divided into a number of connected segments or routines, and where the high speed store is of limited capacity, as is the case with *Ferut*, different routines and the data required for them, come down onto the high speed store and carry out their function in turn. The routines written for the back-water program are as follows :

Data Input—This reads the data of a reach into the machine, and converts the decimally punched information into the binary form used in the computer. Included in the data are identification number, reach length, bend loss coefficient, and area and K factor as a function of elevation. The drum was not adequate to store the data on the whole river and therefore the river was divided into four sections and the water levels calculated over a range of the parameters for each section in turn.

Inverse Data Input—This routine prints out the data on the river in the form of the original sheets used to prepare the data, providing a check that no error had been made by human transcription or machine input.

Master—Checks that the correct data has been used for the run being calculated, and enters the volume of flow and initial elevation into the proper locations.

Reach—Performs the basic iteration of equation (8).

Link, Branch—These routines guide the program to calculate the stations in the proper sequence.

Net A, Net B—These routines define the particular nets. They are different for each net and it is these routines, along with *section* and some constants in *Link* which have to be rewritten for each part of the river.

Section—This routine steers the program from one net to the next. It also plays an important part in the checking of results. On completion of the calculations for all the branches and nets in a section, *Section* causes the entire computation to be repeated using the computed levels as the first approximation in the reach level. A record is kept of the number of times the reach iteration is performed, less the number of reaches in the section. This count is printed out on completion of the check calculation and should be zero if the computed water levels satisfy the conditions required of them.

Iterate—This routine guides control through the various routines used to determine the flows in a net. It calls upon *Net A* to compute the level differences for a given set of flow parameters α, then calls upon

Print E to print the sum of the error terms for the operator's information. If necessary *Iterate* then reads down.

New Coefficients which in conjunction with *Net A* produces a set of partial derivatives which are the coefficients of the equations (7).

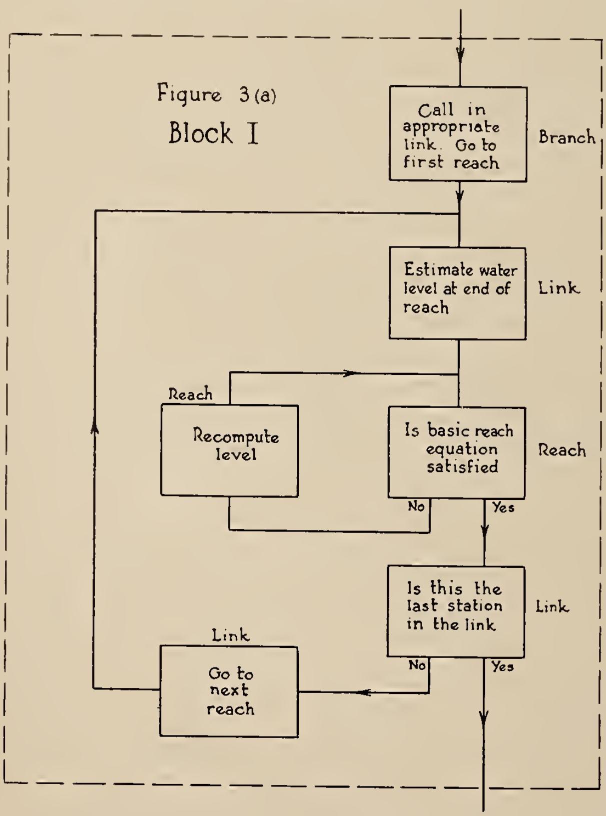
Equation—Solves the system of equations. In the form of the program as used, networks of only six islands or less could be treated automatically, although a net of seven islands could be handled with operator manipulation.

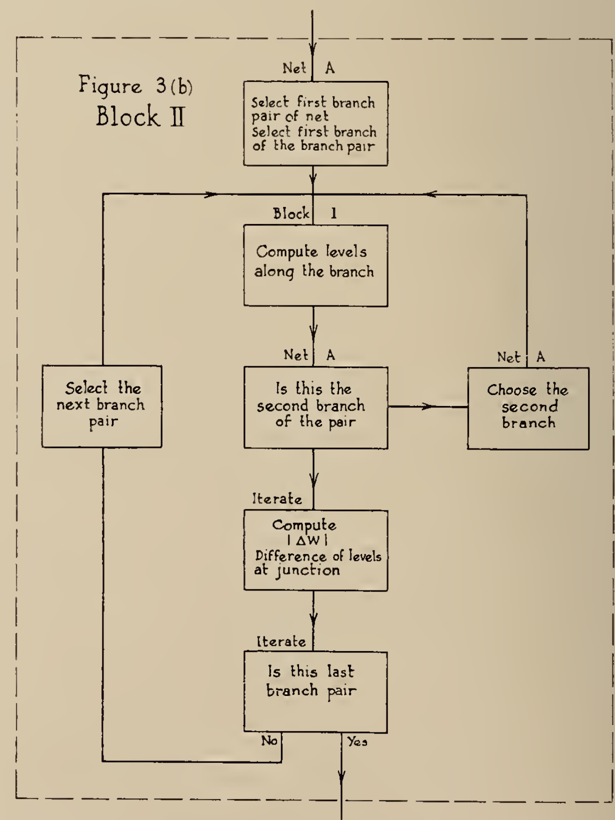
Float Point—This is a standard library routine for dealing with numbers in floating binary notation (i.e. with a power of two scale factor which is automatically adjusted) since the division operation used in the solution of equations will give rise to numbers outside the range of $\frac{1}{2}$ to $-\frac{1}{2}$.

Print Alpha—Prints the flow parameters in decimal form.

Tally—Is a final checking routine which sums all the data and program tracks, compares the sum with known check sums and prints a list of discrepancies if there are any. In this way it is known that no changes have crept in during a machine run.

Output—Prints the identifying data and water levels for the run.





Input/T is a standard library program for reading in the parameters necessary for a different case with the same basic data.

Flow Diagram

Fig. 3 shows a flow diagram for the program, i.e. the sequence of steps necessary to carry out the calculations. It indicates how the steps have been grouped into routines and how the routines follow one another.

Checking Procedures

Not only was *Ferut* one of the first large computers in operation but the back-water calculations were the first extensive computations undertaken with *Ferut*, and much was learned about techniques, now become standard, for doing such computations. Since the reliability of the machine in its early days was relatively low and would not be considered acceptable now, to achieve results which would be used with confidence it was necessary to include numerous checks in the program. Some of these have already been pointed out but the more important checks will be summarized here:

Table I. Input Reach Information

Elevation	*Area (sq. ft.)*	*Conveyance Factor K (millions)*
233	230,600	093.03
234	234,500	095.46
236	242,500	100.80
238	252,500	106.26
240	258,250	111.66
242	266,000	117.37
244	274,000	123.20
246	281,000	129.14
248	289,750	135.23
250	297,600	141.37

1. Checksums were attached to data and programs tapes and these could verify that no errors had been introduced during reading, or during the course of a run;

2. After each run the computed levels were substituted back into the basic reach equation and it was verified that no further iterations were necessary;

3. The solution of the linear equations, obtained by elimination, was substituted back to make sure the equations were satisfied;

4. Frequent restart points were incorporated into the program so that when the machine made a mistake some of the results of the run could still be used;

5. A great many hand calculations were carried out. For example the flow divisions and water elevations in networks were checked for consistency. At selected stations the velocity as calculated by the machine was compared with the value obtained on dividing Q by A. One complete run was computed on a desk calculator, using initial elevations at each reach which were close to, but not exactly the same as those found on the machines. The results for the various runs were compared for consistency and smoothness. At no time was a result which had been accepted from the machine rejected because of failure to satisfy the hand calculated checks;

It was also necessary to take special precautions against human error and the following are some of the checks adopted:

6. The names of all the routines were printed as they were read into the machine to make sure that none had been omitted;

7. The sets of input data were given identification numbers according to the parameters associated with them and the machine checked that the correct set was used for each run;

8. Operating procedures and instructions were carefully written out since only one or two of the people who operated the computer during production were familiar with all the details of the program.

Table II. Form of Computer Results

Run no—012 *Station No.*	Section 1 *Elevation*	Case 0 *Velocity*	*Flow*
00	35.2363	00.73	240,000
01	35.2364	00.79	
02	35.2405	00.66	
03	35.2382	01.03	
04	35.2400	01.21	
05	35.2501	01.02	
06	35.2522	01.08	
07	35.2533	01.13	
08	35.2484	01.65	
09	35.2506	01.84	
10	35.2463	02.35	
11	35.3156	01.27	
12	35.3153	01.56	
13	35.3345	01.31	
14	35.3480	01.27	147,879
15	35.3525	01.28	
16	35.3453	02.01	
17	35.3709	01.73	
18	35.3577	02.40	
19	35.4304	01.31	
20	35.4456	00.99	
21	35.4258	02.14	142,464
22	35.4708	01.64	240,000
23	35.4694	02.06	205,821
24	35.4764	02.17	
25	35.5060	01.93	240,000
13	35.3345	01.31	
27	35.3513	01.04	092,120
28	35.3332	02.29	
29	35.4180	01.17	
30	35.4187	01.41	
31	35.4456	01.11	
32	35.4515	01.07	
33	35.4564	01.06	097,535
34	35.4535	01.75	
22	35.4708	01.64	240,000
36	35.5154	00.51	034,178
37	35.5160	00.77	
38	35.5220	00.65	
39	35.5060	01.93	240,000
40	35.5433	01.37	
20	35.4456	00.99	147,879
45	35.4615	00.08	005,414
46	35.4564	01.06	097,535

Data and Results

The following parameters were required to specify a machine run:

(1) Section number — Because the store was not adequate to contain the description of the whole river, the St. Lawrence was divided into four sections, labelled 0, 1, 2, 3. Altogether in the four sections there were 267 stations;

(2) Case number. Calculations were carried out for both natural and improved channels under both open water and ice-covered conditions;

Case No.	Channel Description
0	unimproved channels, open water
1	unimproved channels, ice cover
2	all Canadian Navigation, improved channel, open water
3	all Canadian Navigation, improved channel, ice cover
4	joint navigation, improved channel, open water
5	joint navigation, improved channel, ice cover

(3) The run number, comprising

(i) Roughness coefficient

Identifying Digit	*n-Natural*	*n-Improved*
0	0.020	0.020
1	0.0275	0.020
2	0.0275	0.0275
3	0.035	0.020
4	0.035	0.0275
5	0.035	0.035
6	0.050	0.035
7	0.050	0.050

(ii) Initial water surface elevation (at Barnhart Island Power House)

Identifying Digit	*Initial Elevation—ft. above sea level*	*Identifying Digit*	*Initial Elevation*
0	233.00	5	240.0
1	235.0	6	241.0
2	236.0	7	242.0
3	237.8	8	243.0
4	238.0	9	245.0

(iii) Discharge — This is the total flow, in c.f.s., leaving the section

Identifying Digit	*Flow—c.f.s.*
0	180,000
1	220,000
2	240,000
3	260,000
4	310,000

Every combination of these parameters was not run, there being 99 runs in all In addition two special dewatering cases describing the conditions of the temporary channel set up while the power-house was being constructed were also run. Table I. shows the input information for a typical reach. This information is preceded by the section, case and run numbers and by *L* the reach length in ft. and *B*, the bend loss coefficient.

Table II. shows the results for a run on one of the four sections. To save time on the relatively slow printer the headings were not actually printed.

The whole calculation required about 500 machine hours spread over a period of some eight months. From the one complete case which was computed by hand it is estimated that 20 man-years would have been required to do the work on desk computers.

Acknowledgements

Each of us (C. C. G. at the University of Toronto, and H. M. M. at the Ontario Hydro) was only one member of a team which helped to set up the backwater problem, carry out the calculations, and interpret the results. At the University particular mention should be made of Christopher Strachey, on loan from N.D.R.C. in the United Kingdom, who did much of the programming and computer organization. Dr. J. H. Chung, of the Computation Centre, and Cecily Popplewell, on leave of absence from Manchester University, also contributed heavily. T. J. Hogg, responsible for liaison between the two groups, worked most effectively on all phases of the problem and he was ably assisted on this by G. V. D. Crombie.

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• BACKWATER COMPUTATIONS PART A

(Continued from page 60)

curves very extensively. Preliminary designs for the water passages in the power dam, the Long Sault Dam and the Iroquois Dam all were based on water levels determined by means of the backwater curves. Plans for rehabilitation of the population in the flooded forebay also were based on the range of levels in the headpond.

One of the major features designed by Ontario Hydro was the plan of channel enlargements between Morrisburg and Chimney Point. To assist in this work two large hydraulic models were constructed, and were used over a period of three years to develop satisfactory designs. In all, a total of eleven hydraulic models were used to develop or prove hydraulic designs or to determine a satisfactory sequence of operations for field construction. Starting or limiting conditions for these model tests were obtained in many instances by means of the backwater curves.

Use of the backwater curves, however, has not been limited to engineers at Ontario Hydro. As was anticipated at the outset, the Seaway entities have based the designs for their navigation locks and canals in the Power Project area on water levels provided by means of the backwater curves. In addition, various other government agencies in Canada and the United States have referred to them frequently.

Many manhours of painstaking effort went into the preparation of the backwater curves. However, their widespread use, and the confidence which was implicit in this use, amply repaid those who were engaged in this work.

Acknowledgement

The decision to make use of the Ferranti computer to perform the backwater computations was a wise one. In less than one year's time, all 99 backwater profiles had been computed, and it is estimated that approximately 20 man-years would have been required to perform the same work manually. This tremendous saving in time was due not only to the performance of the computer, but also to the skill and perseverance of the staff at the Computation Centre under Dr. C. C. Gotlieb's direction, in pressing this difficult problem to completion.

Of those on the Ontario Hydro engineering staff engaged in preparing the backwater slopes, T. J. Hogg and G. V. D. Crombie deserve special mention for their effective liaison work with the Computation Centre. P. S. Quan provided invaluable assistance in the development of the interpolation equations, and also a method for the manual solution of a channel network. Overall supervision of the engineers and technicians engaged in the backwater studies was very capably handled by J. B. Bryce, Hydraulic Engineer, and his assistant, D. G. Harkness.

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THE ST. LAWRENCE POWER PROJECT
REHABILITATION
A Review of Major Features

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Hydro-Electric Power Commission of Ontario.

Presented at the 73rd Annual General and Professional Meeting of The Engineering Institute of Canada, Toronto, Ont., June 1959.

THE CONSTRUCTION of the power development phases of the combined St. Lawrence Power and Seaway Projects forced the dislocation of some 6500 St. Lawrence River Valley residents and the flooding of approximately 20,000 acres of riverfront land on the Canadian side, including seven communities and part of an eighth.

The creation of two completely new communities, Ingleside and Long Sault, and the relocation of Iroquois and part of Morrisburg, were the main features of the rehabilitation program undertaken by Ontario Hydro as one of its responsibilities as joint developer of the St. Lawrence Power Project with its American counterpart, the Power Authority of the State of New York. The task of relocating complete communities, some of which had been in existence for over a century, was a formidable one.

The physical creation of new townsites with roads, sidewalks, waterworks, sewage treatment plants, etc., was a simple matter and one which is being carried out daily in the expansion of towns and cities across the country. The unique features of these townsites were that the residents were being moved from homes and communities in which they had spent a lifetime and relocated in new surroundings with new or moved homes, new churches, schools, shopping centres and recreational facilities. These residents, many of them direct descendants of the United Empire Loyalists who originally settled the area, were required not only to give up their homes, churches, etc., but even a way of life to permit construction of the long awaited St. Lawrence Power Project. The attitude of the residents was one of cautious skepticism, particularly as the Powei Project had been rumoured for over 40 years but had never developed.

Fig. 1 Water Pumping Station at Ingleside.

Hydro's attitude with respect to the St. Lawrence was expressed as far back as 1921 during the chairmanship of the late Sir Adam Beck:

"The lands bordering the north shore of the St. Lawrence River between Cornwall and Prescott were, to a large extent, originally settled by United Empire Loyalists. The best lands in this territory, and consequently the most thickly settled, lie close along the shore of the river. They are among the earliest settled lands in the Province, and the homesteads, churches and public institutions have existed and functioned for several generations. It seems evident, therefore, that if any scheme of development on the St. Lawrence River necessitates the injury, destruction or elimination of these interests and institutions, a sentimental factor is introduced which cannot be appraised as a definite cost item, but to which, nevertheless, due respect must be accorded." *

From the beginning the co-operation of the municipal representatives in the area was sought to solve the problems mutually which would be created in such a program.

The purpose of this paper is to review some of the major features in-

*From Joint Statement by Robert H. Saunders, Chairman, Ontario Hydro, and William K. Warrender, Minister of Planning & Development, Province of Ontario, contained in Proposals for The Rehabilitation of Communities Affected by Construction of the St. Lawrence Power Project, August 17, 1954.

volved in the rehabilitation program. A description of the areas to be flooded is followed by a review of the planning involved and the construction schedule. The actual field program is discussed under the following headings:

1. Municipal services, 2. House moving, 3. Relocation of schools and churches, 4. Shopping facilities, 5. Rental housing, 6. Cemeteries, 7. Cottages, 8. Shoreline improvements, 9. Highway relocation, 10. Railway relocation.

Fig. 2 Aerial view of New Iroquois with Canadian Seaway Locks and Iroquois Dam in background.

Flooded area

The area affected by the new headpond to be formed on completion of the joint Canadian and American powerhouse and the Long Sault dam, extended roughly from the city of Cornwall to the village of Iroquois, a distance of 35 miles. The headpond elevation was established by the International Joint Commission to be 238 ft. above sea level for a period of 10 years or less. Experiments conducted during this period would determine the advisability of operating at an elevation in excess of 238'. Based on these elevations and allowing for seiche conditions, it was decided that virtually all land below the 250 contour would be purchased and the residents relocated.

Communities affected by the flooding and plans for their relocation are as follows:

The Village of Iroquois; This village, situated at the extreme western limit of the flooded area, had a population in 1954 of approximately 1,100. The one major industry in the area, a linen mill, was located at the western limit of the village in the Township of Matilda. This industry was subsequently relocated within the village limits. The built-up section of the village was to be entirely flooded. However, sufficient area remained above the new flood line within the corporate limits of the village to locate the new community.

Matilda Township; Between Iroquois and Morrisburg, a distance of approximately 10 miles, a number of farms and residences situated along the river bank and along No. 2 Highway would be flooded. Some of these residences would have to be purchased outright while others could be relocated on higher ground within their own property limits.

Morrisburg; Located 10 miles downstream from Iroquois with a population of approximately 2000; this community was sustained by three small industries and an active business section which serviced the farming communities surrounding it. The locks of the old St. Lawrence canal in Morrisburg as well as several resorts on the outskirts were an attractive spot for tourists. The flooding here wipes out most of the riverfront homes as well as all of the business section and the locations of the three industries. However, here again, there was sufficient land within the corporate limits of the village to locate a new subdivision and also to relocate the industrial and business sections.

Fig. 3 Moving historic church on house moving trailer. Note extra "dollies" at rear to distribute load. This church was moved approximately 15 miles.

Williamsburg Township; Extending roughly between Morrisburg and Aultsville for a distance of 7½ miles, this was a predominately farming area but also included a large number of cottages situated on the river bank. This is probably the most historic portion of the Valley, being the location of the Battle of Crysler's Farm in 1812. It was also the location decided upon by the Ontario St. Lawrence Development Commission for the reestablishment of a park and memorial to the Crysler battle. Although many of the farmers in this area preferred to move elsewhere to look for new farms, many of those affected took locations in a new subdivision to be created within the township for residences and including sufficient land to operate small garden plots. This new community known as Riverside Heights is situated along the new No. 2 Highway approximately three miles east of Morrisburg.

Osnabruck Township; This township

stretched for approximately 9½ miles along the river and included the hamlets of Aultsville, Farran's Point, Dickinson's Landing and Wales, all of which had to be completely relocated. This too was largely a farming community with the small hamlets which served them. These were all to be combined in one new community at first known as New Town No. 1, but later named Ingleside by its Council. The new community was located roughly in the middle of the township and on the new No. 2 Highway. It is also serviced by the relocated C.N.R. and had access provided to No. 401 Highway.

Cornwall Township; This township stretches for approximately 11 miles along the river and completely surrounded the city of Cornwall. During the life of the Project a large portion of this township was amalgamated into the city of Cornwall. The two hamlets here affected by the flooding were Mille Roches and Moulinette. These two communities were to be combined in one new community known as New Town No. 2, and later named Long Sault, situated on a height of land north and west of Moulinette. This new community overlooks one of the finest bays to be found on the new lake.

In addition to these communities which were affected by the flooding, also the two major transportation routes in the area were affected to a major degree. No. 2 Highway which wound its way along the riverbank between Iroquois and Cornwall was almost completely flooded but a short section between Iroquois and Morrisburg could be re-used as a service road. Also the Canadian National Railways main line between Toronto and Montreal had to be diverted at Cardinal for a distance of approximately 39 miles around the flooded area. A portion of the old railroad bed was used to relocate No. 2 Highway.

Fig. 4 Brick home in Morrisburg being moved by Hartshorne mover.

Planning

It was realized at an early date that any new plan for the rehabilitation of the towns would have to have the co-operation of the municipal councils affected. This co-operation was sought early by Hydro and as a result a close working relationship was established with the six councils affected which did much to ensure the success of the rehabilitation programme. The councils were consulted on all phases of the operation and as such became key members of the planning team.

Frequent meetings were held with councils and public bodies as early as 1953. The first broad plan for the relocation of the townsites was presented to the communities at meetings in August of 1954. This plan was prepared jointly by Ontario Hydro and the Ontario Department of Planning and Development. This was the first of many meetings held with the municipal representatives to create new towns which would be a credit to all concerned. The municipalities were encouraged to retain their own town planning consultants to ensure that their interests were represented and protected. These consultants would be retained at Hydro's expense. By the summer of 1955 general agreement had been reached on the plans and locations for the new townsites and had developed to a point where actual construction could commence.

The design of municipal water and sewage systems was carried out by firms of consulting engineers retained by Hydro for each townsite. These consulting engineers worked closely with the consultants retained by the municipalities to further protect their interests.

Fig. 5 Aerial view of Morrisburg after flooding. Note new shoreline and beach area.


For the Ontario Hydro, the responsibility for all phases of the St. Lawrence Power Project was vested in the Commission's Chief Engineer, Dr. Otto Holden. He was represented in the field by Mr. Gordon Mitchell, Project Director, and Mr. Harry Hustler, Director of Property. Mr. Ken H. Candy, Commission Architect, was responsible for all planning and design features of the rehabilitation program. Prof. Kent Barker was retained as Town Planning Consultant. The author as Rehabilitation Engineer was responsible for field engineering and construction, and co-ordination of the field efforts of other groups.

Co-ordination of the many groups

and agencies involved was a key factor in completing the project on schedule. The rehabilitation schedule had to be closely co-ordinated with other phases of the Power and Seaway Projects. For example, the complete village of Iroquois had to be demolished and cleared to permit disposal of earth excavated from channel improvement projects on Iroquois Point. Similarly cemeteries had to be relocated to permit excavation work to proceed for canal diversions and shoreline improvements. Also close liaison was maintained with the Village Councils, Planning Boards, and church, school and cemetery boards as well as outside agencies such as C. N. Railway, Ontario Department of Highways, the Ontario St. Lawrence Development Commission, Bell Telephone, etc. It is to the credit of these groups that such a complicated program could be completed on time. Despite many differences of opinion there was a general desire to co-operate to bring the Project to a successful conclusion.

Schedule

The actual rehabilitation program began in June, 1955, with the award of the first major contract for construction of municipal services in the Village of Iroquois. By July 1, 1958, the flooding date, the main rehabilitation program was complete.

The following are the main items involved:

1. Development of 3 new townsites and an addition to the fourth including the construction of all water and sewage facilities, power distribution, street paving, etc., for approximately 1150 serviced lots plus serviced lands for industry;
2. Moving and rehabilitation of 531 homes as well as barns, garages and auxiliary buildings;
3. Construction of 9 new schools with a total of 51 classrooms;
4. Construction of 14 new churches and 10 parsonages;
5. Construction of 4 new shopping centres with a total of 90 stores;
6. Construction of replacement buildings for town halls, curling club, skating arena and recreational facilities such as wading pools, golf course, tennis courts, etc.;
7. Construction of 3 new cemeteries and raising two others to relocate 18 cemeteries affected by flooding.

With the exception of final landscaping of park areas, this program was largely completed by the end of 1957, allowing the last 6 months previous to flooding for final clean-up of the flooded area and completion of demolition work.

Municipal services

Some of the major benefits accruing to the new communities were the provision of modern water and sewage facilities, paved roads, new sidewalks and completely new electrical distribution and telephone systems. Two of the communities (Iroquois and Morrisburg), had municipal water systems in their original locations. The remaining communities had no municipal water systems and therefore welcomed this provision in the new townsites. Some of the main features of these services will be discussed here.

1. *Water Supply* — The source of water supply in each case was the St. Lawrence River. Due to the fact that the new pumping stations would have to operate before the water was raised, special care had to be taken to provide interim supplies of water. At Iroquois the permanent intake was installed to allow for operation of the plant under minimum pre-flooding water elevations. At Ingleside and Long Sault temporary intakes had to be constructed to provide water during the period between the time families were moved to the new towns and the headpond was flooded. In Morrisburg a deep shaft was sunk on the shoreline and an intake tunnel driven under the old St. Lawrence canal to connect to the river, presenting one of the more difficult construction problems encountered. A typical pumping station is that constructed at Ingleside and shown in Fig. 1. Equipment installed included one 300 U.S.G.M. and one 600 U.S.G.M. electrically driven vertical turbine pumps and one 600 U.S.G.M. vertical turbine diesel driven pump as a standby unit. These pumping stations were designed for normal expansion of the communities and in some cases were made large enough for additional pumping capacity to be installed. As part of the water supply system in each community, a 208,000 gal. elevated storage tank was erected. Automatic controls were installed to eliminate the full time operation of the pumping stations by an operator.

2. *Sewage Pumping Stations* — In three of the four communities sewage pumping stations were required for all or part of the sanitary sewage flow. In Ingleside the sewage pumping station was required to lift the entire sanitary flow to a gravity line leading to the sewage treatment plant. In Long Sault and Iroquois only a portion of the flow was pumped.

3. *Sewage Treatment Plants* — In the original communities, there were no sewage treatment plants and where sewers existed (Iroquois and Morrisburg) they were generally combined with storm drains. As part of the rehabilitation program and in line with Ontario Department of Health regulations, each new community was provided with a sewage treatment plant. At Morrisburg, Iroquois and Ingleside, only primary treatment was required. However, at Long Sault, secondary treatment was required due to its proximity to Cornwall. A typical sewage treatment plant is that constructed at Ingleside.

4. *Roads and Sidewalks* — Approximately 4½ miles of paved roads

Fig. 6 Trinity Anglican Church, Riverside, before dismantling.

were constructed in each townsite. Paved width was generally 24 ft. but on some main arteries was extended to 28 ft. Surface drainage ditches were constructed on each side, which led to underground storm trunk sewers at several locations. Sidewalks were of concrete and were constructed on both sides of the street.

5. *Power Supply and Telephone*—New power distribution and telephone lines were constructed on the "back-lot" principle. This feature not only improved the appearance of the streets by the elimination of overhead wires, but also aided materially in the moving of houses. Adequate street lighting was provided on concrete poles with underground service wires to the power supply. The Bell Telephone Company took this opportunity to install completely automatic dial telephones in the new communities, providing yet another modern feature.

Fig. 7 Trinity Church as it was rebuilt using salvaged material. Note even the stone and iron fence has been relocated.

House moving

Probably one of the most publicized features of the rehabilitation program was the house moving operation.

In total, some 531 homes were moved in addition to 15 historic buildings moved to the Crysler Memorial Park. The breakdown of the moves is as follows:

Iroquois	151
Matilda Township	28
Morrisburg	93
Williamsburg Township	21
Ingleside	108
Long Sault	130

The above totals do not include auxiliary buildings such as garages, barns, etc., which also had to be relocated.

When an owner was approached by Hydro Property officers, he was given a choice, in the case of a residence, to either:

1) Have it purchased outright by Hydro;
2) Have it moved.

Before approaching the owner, the Property Dept. were advised by the Rehabilitation Dept. as to whether or not the house was suitable for moving. This was based on a survey and inspection of the house to determine its structural qualities, general appearance and suitability for relocation in the new townsite. If this report was favourable and the owner was agreeable to the proposed move, an application was submitted to a house relocation committee for approval. This committee was formed for each townsite and consisted of the reeve and one or two members of Council, representatives of the Town Planning Board, Town Planning Consultant, and members of Hydro's Rehabilitation and Property departments. The purpose of this committee was to prevent unsuitable houses being relocated in the new towns, and also to reconcile all the various problems connected with relocating the families. This group not only approved the move of the house but also its location. Plans were prepared showing suggested house types for each lot. Houses with similar characteristics were grouped together and owners were encouraged to choose a lot designated for their house type, e.g., bungalow, 1½ storey or 2 storey.

An owner proposing to have his house moved to the new town was advised several weeks in advance of the probable date of the move. He was also advised that with the exception of preserves no packing of furniture, dishes or food was necessary. The house would be moved with the furniture intact. Several days before the actual move, moving crews would remove all material stored in the basement to a storage building. This was to allow the foundation walls to be opened for insertion of supporting beams. On the day of the move, the owner and his family were taken to a "stop-over" home which was provided for their convenience. They would occupy this home for a period of one day to two weeks, depending on the amount of work required on their house and also depending on weather conditions. "Stop-over" facilities were required for longer periods in winter to allow for installation of the heating unit. In the summer months, however, many owners returned to their homes the same day. In the case of elderly folk, arrangements were made to board them with friends or relatives to reduce the shock involved in the move.

Despite all the precautions taken, most owners suffered some inconvenience as a result of the move. To meet schedules, many of the homes were moved in winter and landscaping and grading could not be completed until spring. Under these circumstances the co-operation of the residents was remarkable.

The original equipment engaged in the house moving operation consisted of the two Hartshorne house moving machines, winch trucks and extra conventional house moving dollies. Houses up to 150 tons in weight were handled by the larger of the two machines.

The house moving operation in Iroquois, using the above equipment, was as follows:

Each machine operated independently, picking up a house in the old town, moving it to the new location and placing it over the foundation. Due to the width of these machines, this required construction of wide (45 ft. - 50 ft.) access roads between the two locations. In the case of Iroquois this amounted to less than a half of a mile and therefore was not a serious problem. However, as plans were being developed to move to the extreme east end of the Project and commence house moving operations from Mille Roches and Moulinette, the problem of access roads was all-important. In view of this, a different technique in house moving was developed.

A house moving trailer was designed and fabricated which would carry a 100 ton house and which could travel on conventional roads.

This trailer was fitted with a removable goose-neck and had the rear tires and axle units spaced to 21 ft. widths to make full use of the existing roads and at the same time stabilize the load. Using this trailer, one house moving machine was stationed in the old town and one in the new. One machine lifted the house from its foundation and placed it on the trailer for transportation to the new town, and the second machine removed the house from the trailer and placed it on the new foundation. During the summer of 1956 an average of almost two houses a day was maintained by this method. The house moving trailer is shown in Fig. 3 and the Hartshorne mover in Fig. 4.

The house moving operation, although criticized severely at the outset, became accepted more and more as the program advanced. Many owners who had originally decided to sell and build new homes changed their minds and asked to have their homes moved. In virtually every case, the home owner was considerably better off in his rehabilitated house in the new community than he had been before. Provision of a full dry basement, central heating and general repairs including exterior painting, increased the value of his home. More particularly, the shock of disturbance for elderly folk was considerably lessened by being able to return to their own homes after a few days.

Special moves

In addition to the house moving operation, a number of other buildings and structures were moved as part of the rehabilitation program. As mentioned above, 15 buildings of historic interest were moved to the pioneer village being established by the Ontario St. Lawrence Development Commission. The Christ Church from Moulinette was moved intact a distance of approximately 15 miles to the pioneer village. This church was moved on the house moving trailer using additional sets of dollies to distribute the load.

A complete bulk oil storage plant near Morrisburg was moved approximately ½ mile to a new site on the relocated No. 2 Highway. Two 520,000 gal. tanks were moved intact and set on prepared foundations. A gridwork of steel beams was set up inside each tank. The base of the tank was supported by rods suspended from the grid to preserve its shape. The tanks were then raised by jacking at the perimeter at reinforced locations and moved by conventional means.

Fig. 8 Typical view of moved homes on street in New Iroquois.

Schools and churches

One of the first decisions that had to be made was in respect to schools and churches in the flooded area. Many of these could have been moved to the new townsites, while others would have been either too expensive or structurally unsound. Also, it was possible in all cases except Iroquois to combine a number of one-room or two-room school houses situated in the villages into one 8 or 10 room modern school in the new community. Similarly for instance, churches of similar denominations located in such villages as Aultsville, Farran's Point and Wales could be combined into one new church at Ingleside.

For this reason, it was decided to provide new churches and schools to replace those affected. The procedures adopted for churches and schools were roughly identical. The matter of location was in most cases decided by the town planners and agreed to by the Boards concerned during the preliminary stages of planning. When a new church or school was to be built, Hydro first asked the group to form a building committee with whom it could carry on negotiations. This done, Hydro officials met with the building committee and advised them of the procedure to be followed in obtaining the new building. In the case of the schools, the policy was to replace classroom for classroom, keeping in mind modern requirements. The Board was then advised that they could retain an architect of their choice to prepare designs and plans for the building, and to supervise construction. Plans were to be submitted to Hydro for approval before working drawings were started, and working drawings were submitted before tenders were called. The purpose of this was to maintain some uniformity in the quality of construction between the various architects involved.

When the schools were approximately 50% complete the Boards received a furniture allowance to provide new furniture for each classroom. This allowance was approved by the Ontario Department of Education, and was generally accepted as being adequate.

Similarly for churches, the Boards were advised that the churches would be replaced on a per sitting basis and that the architectural treatment would be similar to the existing church; for instance, a brick church would be replaced by a brick church and a frame church for a frame church etc. Within this general framework, the plans of each church were reviewed, revised and approved, and then advertised for tender. Cash allowances were provided for the purchase of new church furniture. The Trinity Anglican Church at Riverside was demolished and the material salvaged and rebuilt in the new community of Riverside Heights. Photographs of the church in its original and new location are shown in Figs. 6 and 7.

Shopping facilities

In the communities to be flooded, the existing shopping facilities were in two categories. First, in Iroquois and Morrisburg, they consisted of a wide variety of stores and shops lining both sides of the main street which in most cases was part of No. 2 Highway. They were generally two or three storey buildings with flats and apartments over the stores. Very little new building had taken place in the shopping area in the past 20 or 30 years, and also little or no modernizing of existing buildings. For these merchants the move to the new shopping centres would not be too upsetting.

They would still retain their old customers and would be able to do business in a modern shopping centre, with adequate parking facilities and located on the new No. 2 Highway. Secondly, in the communities of Osnabruck and Cornwall townships, the shopping facilities consisted of general stores in each of the communities affected, each serving the village in which it was located and part of the surrounding farmland. When these communities were merged into one new community in each township, Hydro was faced with the problem of creating a shopping centre which would include five general stores. Merchants in the communities were encouraged by Hydro to change their line of business to create a more balanced shopping centre. Some switched from general stores to hardware stores and others to appliance stores, and still others into modern supermarket groceterias. With the inclusion of banking facilities, post offices, barber shops, beauty shops, etc., they presented a well rounded business section.

To deeide on the type of building and layout of the new centres, many meetings were held with the merchants and their Councils and also with shopping centre consultants. Merchants were, in many cases, reluctant to accept a single storey building with no living accommodations or apartments overhead as was proposed. However, they finally realized that modern community planning called for separation of residential and business sections, and eventually agreed to the single storey building.

The shopping centres were designed on a very flexible basis to accommodate various types of businesses in self contained shops, each having its own plumbing, heating, and electrical facilities. The buildings are 80 ft. in depth on one floor and are constructed with a steel frame on a module of 20 ft. with a clear span of 40 ft., allowing the installation of various widths and depths of shops.

The exterior walls are of masonry construction insulated and the roof is a steel deck. The shop fronts are of aluminum and glass constructed to the edge of the sidewalk to give the maximum floor area and a uniformity of appearance from the exterior. The sidewalks are covered with continuous metal canopies for the convenience of shoppers. Illuminated signs were provided for each shop which, as well as contributing to the aesthetics, provide light for pedestrians at night. The rear of the shops is divided from the selling space to provide a workshop or storage area with access to a service entrance or for the delivery of merchandise.

Surrounding the shopping centres are parking areas of ample size with small landscaped areas provided on the perimeter and in the mall to complete the aesthetics and encourage transient business.

Most of the owners quickly became adapted to doing business in their new surroundings. Many of them took this opportunity to completely modernize their operations and invested considerable amounts of their own money to bring their stores and fixtures up to the same standard as the new buildings.

Service facilities

In addition to the business men who could be relocated in the shopping centres there were service facilities which had to be relocated. Plumbing and heating shops, service stations and farm equipment dealers were located in areas zoned for this purpose. Probably the most difficult problem was that of deciding on locations for the service stations. In Morrisburg, for instance, there were six stations to be relocated and all were insisting on locations on the new No. 2 Highway. Highway regulations re siting of service stations are much more stringent now than when these stations were originally located. After considerable negotiations between service station operators and the Department of Highway officials, suitable locations were found. Similar problems existed in all four townsites.

Rental housing

As well as the problem of rehabilitating those who owned their own homes in the area to be flooded, there was the problem of providing accommodations for tenants. In nearly all cases encountered, the owner of a rented house did not with to retain ownership in the new community. This meant that he took a cash settlement for his house and Hydro was left with the responsibility of relocating the tenant. Also, there were a large number of tenants living in the apartments and flats over the business sections in both Iroquois and Morrisburg. In Morrisburg this tenant group represented approximately 40% of the people affected. The same situation was true to a lesser degree in the other two communities. This problem of relocating tenants was solved as follows:

In Iroquois a large number of the homes purchased by Hydro were acceptable for moves into the new town. Even though the owners had decided to purchase or build new homes, Hydro arranged to move their old home into the new community and to use it for rental purposes. There were also a number of large homes which could be readily converted into two or three apartments. This helped to provide accommodation for smaller families. When this accommodation had been exhausted, 12 units of row housing were built to accommodate the remainder. However, in Morrisburg there were not sufficient older homes that could be moved economically and used as rental accommodation. Therefore, a program of row housing was undertaken which provided 84 units. These were two storey buildings with 4 or 6 units per build-

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Fig. 9 Aerial view of new town of Long Sault. This town combined residents from Mille Roches and Moulinette.

A PROFESSIONAL OUTLOOK

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LIVING at a time of extreme pressures, most of us simply have more things to look after than time permits. We are hard put to keep up with developments in our own professional field, let alone spend our time in learning about others. But if we are ultimately to play an effective part in any overall plan, there must, somewhere along the line, be a blending or a meeting of direction and scope of our activities. What is the nature of the particular outlook that a professionally qualified person should bring to life and its problems? What is the difference between a person who has a professional outlook and one who has not? In other words, what is the difference between an engineer and a professional engineer?

In Webster's New International Dictionary, Second Edition, we find the word "professional" defined as follows: "Of, or pertaining to, a profession, especially a learned or skilled profession; characteristic of or conforming to the technical or ethical standards of a profession or an occupation regarded as such". There are further definitions but we will deal with these for the moment. Let us look then at the first portion of this.

"Of or pertaining to a profession": This is a type of classification that a great many people use. That is, we often think of a profession as being related to a particular classification of work. We think of law, of medicine, of theology, as being professions. In recent years engineering, accountancy, nursing, and still more recently dietetics and social service, have come to be regarded as professions. We think of engineering work, of legal work, of medical work as professional work. In other words we can and often do recognize occupations as professions by the type of work which is done by those who engage in that particular profession. It will be readily seen, of course, that this yardstick does not get us very far. As a matter of fact logically it takes us in circles, but it is a yardstick which is readily applied and it is perhaps used so often because of its readiness in application. To simply say that a profession is any one of a number of types of work is a much too shallow basis to use as a definition.

Let us look then at the next definition which is "characteristic of or conforming to the technical . . . standards of a profession". Here we see another approach. Here — see the profession as a form of activity for which specialized training is required. Law, medicine, and theology were the traditional so-called "learned professions" and around these three avenues of study the traditional University training was centred. However, engineering, accounting, nursing, household science, and other fields of activity are now included in such specialized training and we think of people in these fields as being professional because they are highly trained, having pursued extensive study above the high school level. This we will see is also a very handy yardstick and one that is easy of application. But again it is somewhat superficial to say that a professional man is simply one who knows more about some particular field of endeavour than do others. This is not to place him upon the plane to which he should aspire. This element is of course usually present in a professional man, but to adopt it as the basis for distinguishing him from other people is simply to adopt a part for the whole.

Looking then at the next definition which is "characteristic of or conforming to the ethical standards of a profession", we find ourselves on a higher plane and members of a profession would be the last to minimize the importance of ethical standards. But a professional man needs more than ethical standards, important as these are.

The problem presents scope for further analysis: we find, of course, in defining the word "professional" the same type of problem met in defining most other words. A term that is used in such a general way to cover such a wide range of activities must always present us with something of a problem in semantics. A suggested definition is as follows: "A profession is a self disciplined group of individuals who hold themselves out to the public as possessing a special skill derived from training or education and who are prepared to exercise their skill primarily in the interest of others".

Here several elements will be noted. A profession initially is a group—you do not have a profession consisting of one person. It is also self disciplined. This indicates a considered determination of its aims as well as of its rules of conduct. Thirdly, those comprising it hold themselves out to the public as possessing special skills. That is, they purport to have special qualifications and the public should be able to rely upon this representation. Lastly, but perhaps most important, a profession exists for the purpose of serving others. In other words, a profession is not organized for its own advancement. The purpose of the lawyer is to make the law work. The purpose of the medical profession is to see to the health of the community. The purpose of the accountant is to help people keep their affairs in order. The purpose of the teacher is to bring out the knowledge of those entrusted to his guidance. The purpose of the engineer is to see to the efficient use of our resources in the furtherance of our social destiny. But whatever the profession, it is suggested that its primary purpose should not be private gain. It is to be distinguished from a trade or from ordinary business activities in that it exists or should exist for service to others. This is the mark of a true profession and should be contained in the outlook of a professional person.

From this it may be inferred that a proper attitude of mind is perhaps the most important characteristic of a person with a professional outlook. This attitude of mind should distinguish those in a profession from those without. You can have several people doing the same type of work with a difference in attitude and it will make a great deal of difference in the result of that work. It is said that when Sir Christopher Wren was supervising the construction of St. Paul's Cathedral he came upon three workmen dressing the same stone. He asked the first man what he was doing. The reply given was that he was dressing the stone. He asked the second what he was doing and the reply was that he was supporting his family. He asked the third man what he was doing and he replied, "I am helping you, sir, to build this Cathedral". Each of these men had a proper motive and the third man was not necessarily engaging in a profession. But he certainly had the professional outlook because he saw more clearly than did his fellow workmen the purpose and objective of the work he was doing. He viewed it in its wider aspects and other things being equal, no doubt such a man would do a better job of dressing a stone and would go farther in his chosen occupation than the other two would.

It will be apparent that a professional person has three groups of people with whom he should concern himself. The first of these is those whom he serves, the lawyer his client, the doctor his patient, the teacher his pupil, and the engineer whoever engages his services. Secondly there is a relationship with others in his profession. In other words, a relationship with his colleagues or other people with similar qualifications doing similar work and endeavouring to achieve similar objectives. Thirdly, of course, there is his relationship with society because after all, a professional man is still a citizen and he should be among our very best.

Let us now turn our attention to these three relationships of the professional man in turn. First there is his relationship with those whom he directly serves. This, of course, is most important because after all here the professional man is dealing with a person who is paying him. It is obvious that the professional man must be adequately trained to give the necessary service. But training itself is not enough. He should be adapted to the particular type of calling in which he is engaged. But assuming that he is adequately trained, he must also be industrious and toil diligently in the interest of his client, or his patient, or by whatever other term he may refer to the person who is retaining his services. Our concern for the professions may take another direction. Our Universities and other training institutions are aware in this age of sputniks of the necessity of keeping pace with the times. The challenge of present day developments is tremendous, not only in the field of technology but also in the field of social organization. There are so many fields of research and of social and technical development that training facilities are taxed to the limit. Yet I do feel that our authorities are, by and large, fully aware of the necessity of expanding and looking after this formal part of professional training.

A great many of our professional people engage in what might be called competitive fields and here I have not so much fear for lack of competence. If the lawyer, the doctor, the accountant or the engineer is not competent he just will not get his share of the business. Any man who wishes to succeed in any such competitive field will find that he will have to work and work very hard. As a matter of fact the pressure of this work will be one of his greatest problems. There are some professions which are not competitive in the same sense and there is perhaps here more need of awareness on the part of the profession that industry, diligence and proper training are at all times essential. Taking the teaching profession as an example, it is perhaps somewhat easier for a teacher to lower his standards and still hold his job than for some other people. A teacher in a large institution with a well organized profession behind him can get along on a minimum of work. The same is true of almost any professional man working, for example, in the civil service. Fortunately, however, this seems to be the exception. But it takes a real professional attitude and a sense of responsibility for one who is secure in his appointment to keep himself constantly on his mettle. If he has a professional outlook he will do it.

We are speaking of the responsibility of the professional man to those he serves. This relationship must, of course, be closely watched. A lawyer, for example, should perhaps have no dealings whatever with his client that are not purely professional, and the same is probably true of an engineer. It is bad business for a professional man to borrow and lend with a client. The professional man who makes a business deal with his client, in which he has a personal interest, departs from the straight professional course, courting embarrassment and perhaps even disaster for the obvious reason that he cannot deal with his client on equal terms. He has the advantage and if the business arrangement does not work out satisfactorily, the professional man stands to suffer in reputation. This is certainly true in law. Law, it has been said, is a jealous mistress and the professional canons of all professions rightly impose definite moral restrictions on those who enjoy the benefits that come from membership in that profession. A lawyer should not confuse his professional duties with his own business interests and in a greater or less degree this applies to all other professions.

The professional person, of course, in dealing with those whom he serves must keep his independence. An engineer should never be the mere tool of his employer. The lawyer should not be the mere mouthpiece of his client. In each case the engineer and the lawyer should be the adviser. So should the doctor; so should the accountant; and so should any other person giving professional advice. No professional man should put forward an unreasonable proposition based on the fact that he has been told by his client or his employer that this is the desired course of action. All professional people should be required to do only that which is professionally proper and not that which an employer or client proposes. A professional man is not merely an agent of the party who hires him. All professional people must have standards and they must set these standards themselves. They cannot let the people who buy their services buy the right to set their standards.

A professional person should, of

course, keep confidential his relations with those he serves. This applies almost without exception to people in positions of professional responsibility. Certainly it is true with the doctor, with the lawyer, and with the accountant and presumably it is equally true with the engineer. A professional man must regard his client's, his patient's or his employer's problems as of great interest to himself as a professional man. He must view them as his immediate and direct concern but he must never lose sight of the fact that the problem is still not his problem but is rather the problem of the one he serves. Anyone who places his trust in a professional man is entitled to have that trust, whatever it is, kept in the utmost confidence.

Professional confidence can go very much farther than some people take it. The responsibility of the professional man to his client or his patient, or whoever he may be serving, is both onerous and demanding. But no less important is the relationship to his colleagues. It goes without saying that it is the responsibility of every professional man to have both a sense of loyalty and a sense of responsibility toward others in his profession. This does not mean that he should condone failure to measure up to the standards of his profession, but among professional people there should be no cut-throat competition. He should see that it is to his interest as well as to that of others to keep the standards of the profession high. He should take an active interest in his colleagues, particularly the younger practitioners. He should give assistance to bring them along so that they may develop in the proper way. When time then comes for these younger members to assume control they will have a background both from precept and example which will enable them to further enhance the standards of the profession. In other words, a professional man should be far-sighted with his professional interests in view. He should be just as jealous of the respect and prestige that his profession will enjoy twenty years from now as he is of the present.

While the professional man's relationship with his client and with those whom he serves will play the larger part in his professional life, a great deal of the enjoyment of his profession, as well as a great deal of his success, will depend on his relations with his fellow practitioners. It is, I am sure, more important for a lawyer, for example, to enjoy the good opinion of the profession than of the public, important as this latter may be. A lawyer can succumb to ambition to please people, to please juries, to get his name in the paper, to become a subject of conversation amongst spectators, yes and among loungers of the court room. Things which may pass for eloquence with the masses may really be not only ineffective but even undesirable. However, if his ambition is to please his fellow practitioners, he can never be misled. As Lord Sharswood has said, "Their good graces are only to be gained by real learning, by the strictest integrity and honour and by attention, accuracy, and punctuality in the transaction of business". It is very pleasant to have public acclaim but probably the truest test in a profession is the estimation in which one is held by colleagues. This is not always the case. In all professions, of course, jealousy and other unprofessional attitudes may creep in but by and large an engineer who is respected and admired by other engineers has earned that respect the hard way. A lawyer who is known as a "lawyer's lawyer" is paid the highest compliment that can be given to him. A physician who is regarded by other physicians as being outstanding and capable will in almost every instance be found to be worthy in every sense of that accolade. A professional man who is well regarded by his colleagues is in a happy position and is well on the way to not only a successful but a most enjoyable career.

The third and final relationship, but by no means the least important, is the relationship of the professional man with society at large. Those of us who are privileged to be in professions enjoy an importance in the eyes of society out of proportion to our numbers. Now this influence is something of a trust and it must be carefully exerted. There is a heavy responsibility on every professional group both individually and collectively to see that the contribution which it makes to society is both adequate and proper.

Members of professional groups are given special concessions by society and we must appreciate that these are given in trust. Physicians have a monopoly on the practice of medicine. Lawyers have a monopoly on the practice of law. Engineers have a monopoly on some phases of our industrial and economic life. Chartered accountants have a monopoly on some aspects of our businesses. Now these are special concessions. They are given by society to the professions in trust and they must not only be carefully guarded and watched, but members of professions should realize that they owe this debt to society. In addition to special concessions, of course, all professional people naturally cost the country money. It costs the country millions of dollars a year to train people to professional competence, and while we often attribute our own accomplishments to our own efforts, we should not be forgetful of the circumstances which made it possible for us through our own efforts to arrive where we are. Our opportunity was made available through the united efforts of those who comprise our society. If any groups in the nation should have a sense of social responsibility it should be professional groups.

It is not suggested that every engineer should go into civic politics, or that every professional person should feel obligated to become the member of a political executive or a school board, but what we should do is to avoid allowing our affairs to become so ordered, or so disordered that we have no time for anything else. Any professional person who becomes so immersed in his own work or his own advancement that he has no time for the important things that are going on round about him is courting disaster not only for himself, but for others. We are not all interested in the same things. We do not all have ability along the same lines. But there is a place in this complex society of ours for the efforts of everyone and there is particularly a place for the highly trained competence that comes from membership in a professional society. This nation has been kind to our professional people. In spite of the fact that we must work for what we get, the opportunity to work at our present level constitutes a social debt of which every professional man should be acutely conscious.

Anyone purporting to have a professional outlook must be prepared to accept heavy responsibilities. The professional man should be self disciplined. He must work hard to further his skill in his own particular calling. But above all he must be prepared to faithfully serve those who need his services. Anyone whose primary interest is in private gain should never enter a profession because few professional men die wealthy and those who do usually do not acquire their wealth from fees.

But if a young man picks a suitable profession he has indeed made a happy choice. Professional life is filled with variety and interest. It is filled with constant challenge. It is filled with the opportunity to really help people with their problems, to help them to realize their dreams, and often to give them help that is available from no other quarter. There is no reason why a professional man should not look forward eagerly to each day. If he does the type of work in which he is interested; if he brings average intelligence to bear upon problems and handles them with industry, he will do a good job. And if he gives good service people will come to him and his income will be adequate. Any good professional man, of course, can expect a modest competence. Some make a great deal of money. But to anyone who is professionally minded, this is not the chief reward. A professional outlook sees far past this. To the man who is true to his profession the horizon must be much wider.

THE ST. LAWRENCE POWER PROJECT

REHABILITATION

(Continued from page 73)

ing, each unit self-contained and including 3 bedrooms. In addition, to accommodate some of the older tenants and also for those with smaller families, 12 semi-detached units were built of similar design but including only two bedrooms. In the two communities at the eastern end of the Project, there were sufficient moved houses to accommodate all the tenants involved.

Cemeteries — In the area affected by the flooding were some 18 cemeteries. Two of these, one in Iroquois and one in Morrisburg, could be raised and remain in their original location. Three new cemeteries were created to replace the remainder. One of these, now known as the St. Lawrence Valley Union Cemetery, combined 13 of the cemeteries located in Cornwall, Osnabruck and Williamsburg townships. A site was chosen near the original hamlet of Wales, situated between the new shoreline and the relocated No. 2 highway. Sections of the new cemetery were allocated to the four religious denominations involved with sufficient lots provided for future interments.

Cottages — Scattered along the shoreline from Iroquois to Cornwall and also on Sheik Island near Mille Roches were some 250 cottages. To provide for relocation of these cottages Hydro allocated one whole and part of another island to be developed as cottage sites.

Highway relocation

The relocation of No. 2 Highway which connected seven of the eight communities affected was carried out by the Department of Highways of Ontario, Ottawa District. Close liaison was maintained between Highway engineers and Hydro as to location and scheduling as it was necessary that the schedule be closely related to the power phases of the Project. Despite some particularly poor construction weather in 1956, co-operation of all concerned kept this phase of the program on schedule.

Railway relocation

Similarly the C.N.R. main line connecting these communities had to be relocated. Diverted at Cardinal, a new double track line was built for approximately 39 miles re-connecting at Cornwall. Design of all features connected with the railway relocation including track location, five railway stations, switches, sidings, communications and signal equipment was carried out by the Canadian National Railways, but the field engineering and contract supervision was the responsibility of Ontario Hydro. Here again, close liaison was necessary as large sections of the original track had to be removed to allow construction of major features of the project at Mille Roches and Iroquois.

Conclusion

It would be extremely difficult to measure the effect of the program described above on the future of the communities affected. In a physical sense, everything is in their favour for an era of expansion and growth. New municipal services, schools, churches, civic buildings, shopping centres, and modern transportation facilities via highway, railway and water are attractive features for industries both large and small. The development of the extensive park land along the shore of the new headpond will within a few years make this area extremely attractive to tourists. The economic possibility of deep water harbours will also encourage industrial expansion.

Equally important is the new spirit and enthusiasm which has developed among the residents and their elected Councils. This if continued, should bring a new wave of prosperity to the area.

DISCUSSION

of Technical Papers and Other Articles

CONTROL OF MOVING ICE IN THE U.S.S.R.

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The recently published textbook by Professor A. M. Estifeev[1] is a valuable addition to the list of references on frazil ice given by G. P. Williams[2] and covers a broader field as it deals with all types of moving ice. The contents of this article are based upon material in this textbook except where otherwise noted.

Ice Processes

The four major factors affecting ice processes are:

1. Water velocity (low velocities, v, and high velocities, V);
2. Heat content change (continuous cooling, s_c, and periodic cooling, s_p);
3. Morphological conditions (M);
4. Wind velocity (w).

The four basic combinations of water velocity and heat content change are (v,s_c), (V,s_c), (v,s_v), and (V,s_v).

The first process involves a progressive growth of ice and the establishment of a rigid ice cover on channels with velocities of up to 0.5 metres per second and with air temperatures of -10° C. and cloudy skies.

The second process gives rise to prolonged and intense shooga (conglomerations of frazil ice, small ice chunks, etc.) formation.

The third process involves temperature fluctuations (due to waves of cold and heat) which prevent the rapid formation of a surface ice cover, even when velocities are low. Polinias (unfrozen patches) act as sources of supercooling and shooga formation, causing zazhor (shooga) jams downstream. Warm spells cause thin ice to break up and hence zator (surface ice) jams, the displacement of shooga masses and hence zazhor jams, the floating up of anchor ice, and zator-zazhor jams.

The fourth process is similar to the second but is less severe (as it only occurs periodically) except when a shooga cover is formed in the second case.

An important effect of ice processes is the steepening of the surface profiles of channels.

Wind effects and morphological conditions (forms of cross sections, presence of natural and artifical reservoirs, bends, islands, channel constrictions, lake outlets, etc.) are analyzed in a systematic manner in conjunction with the study of any one (or different combinations) of the above processes.

The following nine components are summed to give the resultant heat content change:

- $^s1$—Evaporation (emission);
- $^s2$—Convection (emission);
- $^s3$—Radiation (emission);
- $^s4$—Direct solar radiation (absorption);
- $^s5$—Diffused solar radiation (absorption);
- $^s6$—Heat exchange between the bed and the water;
- $^s7$—Internal friction (absorption);
- $^s8$—Atmospheric precepitation;
- $^s9$—Inflowing exterior water.

Rational universal quantitative easily-applied mathematical formulae for each of the above components are listed by Professor Estifeev. The apparent complexity caused by the large number of variables and components is reduced by the fact that $^s8$ and $^s9$ can usually be neglected and that certain of the other seven components have relatively insignificant values in most practical cases. The values of all components must be determined in each specific case, however, as a component neglected in one region and in one case may be important in another.

In the case of shooga-bearing channels in Central Asia, an example is cited to show that $^s1$, $^s6$ and $^s7$ are small in comparison with $^s2$, $^s3$ and $^s4$, and $^s5$ is only a small percentage of $^s4$ at noon on a clear day in November and for specific meteorological and hydraulic conditions.

An increase in w leads to an increase in both $^s1$ and $^s2$. For the conditions cited in the above example, for instance, a fivefold increase in w (from 2 to 10 meters per second) causes $^s1$ to triple and $^s2$ to double; $^s1$ is still only a small fraction of $^s2$, however, even at the higher velocity.

Under conditions similar to those in the above example, s is a measure of the total heat emission from the water surface. Plotting air temperature versus s for a specific time of day and specific sky conditions shows that s equals zero at a specific temperature which is known as the critical temperature. The critical temperature is fixed by the combination of meteorological factors in the basin. In many cases forecasting can be based upon this temperature alone as it is an indirect measure of all the principal components of heat emission and can be determined theoretically for a given region. Experience on Central Asian rivers demonstrates the complete applicability of these assumptions and good agreement between calculations and observations.

Controlled Regimes

The importance of controlled regimes is emphasized. Storage, transport and bypass regimes are analyzed and rigorous mathematical analyses are presented.

A shooga carpet is completely preserved when velocities are less than 0.7 metres per second and commences to disintegrate when velocities are equal to or greater than 1.3 metres per second; complete mixing of the shooga in the flow occurs when velocities are equal to or greater than 2.0 metres per second.

Shooga discharge can be computed or determined experimentally. Intricate physical and mathematical analyses are presented. Measuring devices based on the calorimetric principle (change in volume of mixture after shooga is melted, electrical energy required to liquify and heat sample, water temperature at end of tube after shooga passing through it has been liquified and heated) are recommended in preference to devices measuring the volume of shooga after water has been drained off. Measuring procedures are given.

Local Measures

Modern methods of *heating screens* and bypassing shooga through unique *vortical funnels* around turbines described by Professor Estifeev are of special interest to hydropower engineers.

Unique types of inexpensive *dams* are of more general interest and will be described briefly.

Debris dams are created by blasting steep slopes into river valleys. In Uzbekistan, for instance, approximately 250,000 cubic metres were displaced by blasting to create a dam with a body of 40,000 cubic metres, thus saving 4,000 man-months. Conditions required for this type of construction include a large vertical distance between the center of gravity of the displaced mass and the river bed; impermeable base and walls for the dam, erosion-resistant rock, general slope of rock strata such as to impede infiltration, easily-displayed rock in the upper section of the valley, and favourable topographical conditions (U-shaped or V-shaped gorge with steep walls to a considerable height).

Large ice flows are passed over inexpensive *rockfill overflow weirs*.[3]

Structural element dams are unique in that the entire river flow can be passed through the structural elements without overtopping them. One series of tests[4] with structural elements on a stone base and with stone protection showed that when the head is 4 metres a discharge of 4 cubic metres per second can be passed through a dam composed of elements weighing 1,700 kilograms (7 cubic metres of concrete per linear metre).

Stone, stone-brushwood and teepee dams and combinations of these three types of structures are recommended as shooga-retaining works for the foothill reaches of Central Asian rivers. Three logs, lashed together at the top, are used for each teepee, and stones and brushwood are piled around its base. Larger teepees are held in place by anchors formed from gabions (screens filled with stones). Angle iron members used as cross-beams aid in the rapid settling out of frazil ice and hence in a more rapid accumulation of shooga.

Cable dams are arranged in several rows at a distance of from 800 to 1,000 metres from each other. The use of two or three rows is desirable. The upper ends of the cable network are attached to pontoons placed at intervals of from 12 to 15 metres across the channel and the lower ends are held down on the river bottom by anchors. Calculations are based on the assumption that the dynamic force on the network is equally distributed between the cable and the anchors and that the entire river channel is choked with shooga.

Metal hedgehogs consist of iron rods hung from a cable stretched across an open channel; star-shaped units of small rods are attached to each main rod. The metal rods aid in the rapid settling out of frazil ice and hence in the formation of ice jams.

Timber booms parallel to the flow are used to guide ice while timber booms perpendicular to the flow are used to retain ice.

Certain of the above structures are built at river bends where the width is large and the depth small, and where part of the ice thrust can be transmitted to the river bank.

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2. "Frazil Ice", G. P. Williams, Engineering Journal, November 1959.
3. "Opyt Stroitel'stva i Eksputatatsii Uluchshennykh Tipov Vodoslivnykh Plotin Iz Kamennoy Nabrosky", N. N. Belyashevskiy, Akademiya Nauk Ukrainskoy SSR, Institut Gidrologii i Gidrotekhniki, Izdatel'stvo Akademii Hauk Ukrainskoe SSR, Kiev, 1957.
4. "Karkasnaya Nabroska Dlya Perekrytiya Rusel Mnogovodny Rek", Prof. S. V. Izbash, Kh. Yu. Khalbre i G. Ivanov, Gidrotekhnicheskoe Stroitel'stvo, 1954, No. 4.

Note: A mailing list for translations of sections of the above and related Russian-language literature (to be printed in several months) is being compiled by the writer.

BUSINESS TRAINING FOR PROFESSIONAL ENGINEERS

R. J. Bedard, *Former Editor of "Genie Construction". The Engineering Journal, November, 1959, p. 75.*

Author's Reply

In reply to Prof. B. M. M. Carpendale, to Prof. P. B. Hughes and to Prof. V. Jolivet.

To what extent can engineering schools give their students effective business instruction at the undergraduate level is a question to which at present I have no answer. Therefore, I cannot comment on the decision of Varsity to suppress Course IV and to create another undergraduate course in Industrial Engineering.

This however, does not contribute much to the solution of the problems faced by the engineer turned — or about to turn — manager.

The change at the U. of T. does not much affect my argument since the focal point of my paper was the creation of opportunities for *graduate and post-graduate* studies in administration by Canadian engineering colleges.

My reasons for thinking that graduate education in administration is a function of engineering schools are three. They are rooted in what I consider to be the responsibilities of colleges of technology:

1 — to the engineer as an individual;

2 — to engineering as a profession;

3 — to society as a whole.

Full discussion of these points would take more space than *The Engineering Journal* can supply for this comment. Therefore I will limit myself to a brief outline.

Responsibility to the engineer as an individual

If I am not mistaken, the aims of engineering education — and for that matter, of all university education — are: a) to impart knowledge; b) to strengthen intellectual powers; c) to develop attitudes. These objectives are simultaneous. The order of presentation is by no means an order of importance. Further, I find myself in agreement with Prof. Carpendale's remarks about the personal factors in teaching.

a) Knowledge. Canadian engineering schools are generally doing a good job in transmitting technical information. However, technology is not all there is in heaven and earth. Man, for instance, is certainly as worthy of an engineer's attention as any other phenomenon.

Now, in the transmission of knowledge, engineering colleges may say little or nothing about man, and leave the students under the impression that man is just another thing. The previous generation did that. Engineers went and applied to the handling of men, knowledge and methods effective in the handling of things. The result? Technologists went to the College of Hard Knocks. There, they have experienced enough trouble to become wiser.

The automobile industry, for in-

(Continued on page 156)

AUTOMATION AND CONTROL ENGINEERING IN CANADA

Instrument Installation in a Modern Chemical Plant

R. E. Bark, *Engineering Department, Du Pont of Canada Ltd.*

WITH THE INCREASING quantity and complexity of process controls in modern chemical plants, it is imperative that adequate consideration be given to the methods used in their installation. In a multimillion dollar plant, with its growing use of such sophisticated equipment as continuous stream analyzers and computer controls, it is not unusual for the installed instrument cost to exceed 10% of the total value of the plant. This is a heavy investment and the days when the instruments were hung on the process as appendages, and treated as necessary evils, have long since passed. If sufficient thought is not given to installation, then maintenance and trouble-shooting become difficult, resulting in serious losses in production while the source of the trouble is bieng located.

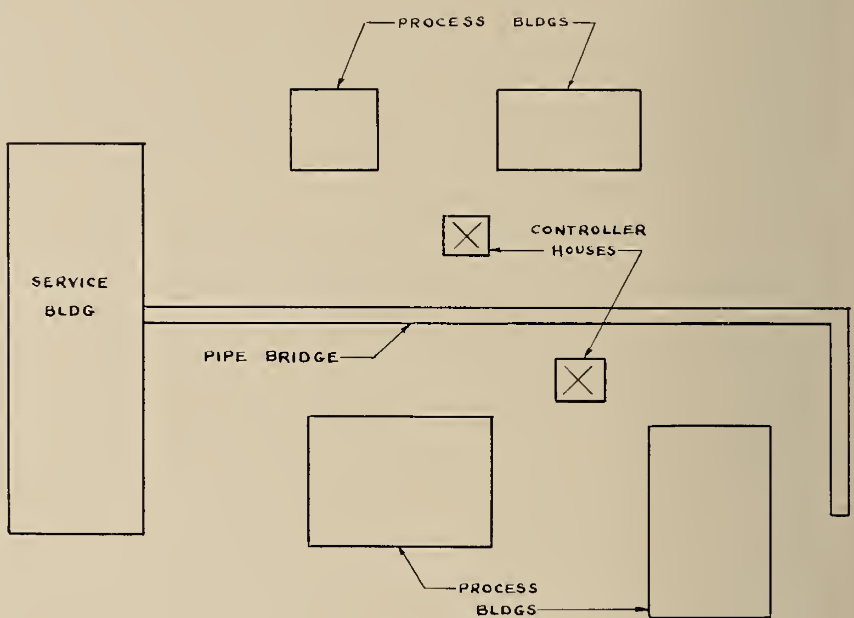
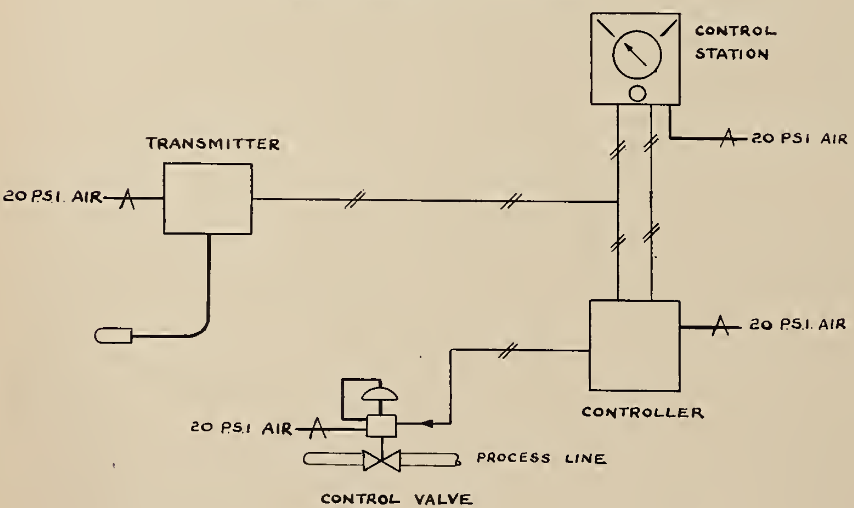


Fig. 1. Plot plan.

In the petro-chemical industry we are faced with some recurring problems in the design of most new plants. Many of the materials which are handled are toxic or of an inflammable nature. This is one of the reasons why we construct open buildings, which reduce or eliminate the problem of fume removal. Several other difficulties, however, are introduced, among which are weather-proofing and steam tracing. In addition, since there are no walls, other suitable means must be found for installing and supporting piping, tubing and the instruments. The following description of some of the design considerations for a plant, using open buildings and handling hazardous materials, could be applied to several of the facilities which we have designed and built in the past few years.

Fig. 2. Simplified control loop.



One of the questions which must be answered very early in the design stage, is the location of the central control room which contains the main operating panel. As will be seen from the plot plan (Fig. 1) this is located in the service building which is some 300 to 500 ft. away from the process block. This building houses the control room and shops. There is usually considerable debate between the operating personnel, the process engineers and the instrument engineers before the final location is determined. From the operating standpoint it is highly desirable to have the control room in a location which provides easy access to production and technical supervision. Since the process may be handling hazardous materials, it is also desirable to have the control room removed from the process block so that an orderly and safe shutdown can be effected in case of fire.

The instrument engineer, while appreciating these points, must of necessity attach much more importance to the performance of the instruments which he is going to install. To provide a little information for those not familiar with the elements of a modern control system the main parts are shown in Fig. 2. The transmitter measures and delivers a pneumatic or electrical signal proportional to that value. It follows, then, that the transmitter must be located at the point of measurement in the process. This is also true of the control valve, where the final regulation takes place. Of the other two elements the control station must be located on the main control panel. This is the unit on which the operator can see the indication on record of the process variable, and where he can vary the control point, or by means of a knob can by-pass the controller and adjust the control valve manually. The controller is a separate unit which can be connected directly to the control station or remotely mounted in the field, close to the control valve. In general it can be stated that the closer the controller is to the control valve the better it will respond to upsets in the process and take corrective action. The instrument engineers know that many of the loops will not provide proper control if the transmission lag resulting from a 500 ft. separation

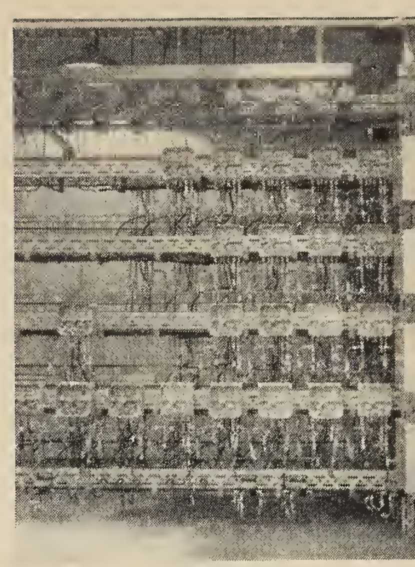
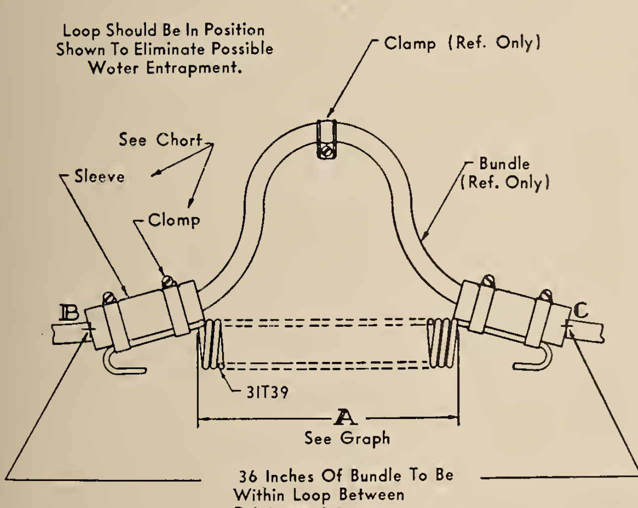


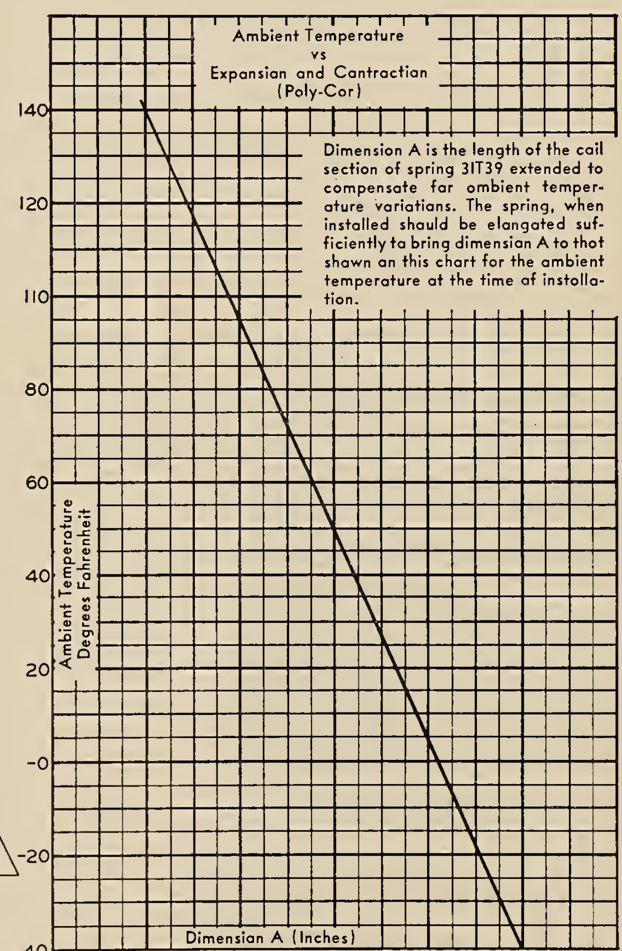
Fig. 3.

were introduced into the circuit. This means that a number of the controllers

Fig. 4. Expansion Loop Assembly.

Part No.	Bundle Size	Sleeve	Clamp
11T35-P1	1/4-4 Line	31T40-P1	31T6
11T35-P2	1/4-7 Line	31T40-P2	31T6
11T35-P3	1/4-10 Line	31T40-P3	31T6
11T35-P4	1/4-12 Line	31T40-P4	31T6
11T35-P5	1/4-14 Line	31T40-P5	31T6
11T35-P6	1/4-19 Line	31T40-P6	31T6
11T35-P7	3/8-4 Line	31T40-P7	31T6
11T35-P8	3/8-7 Line	31T40-P8	31T6
11T35-P9	3/8-10 Line	31T40-P9	31T41



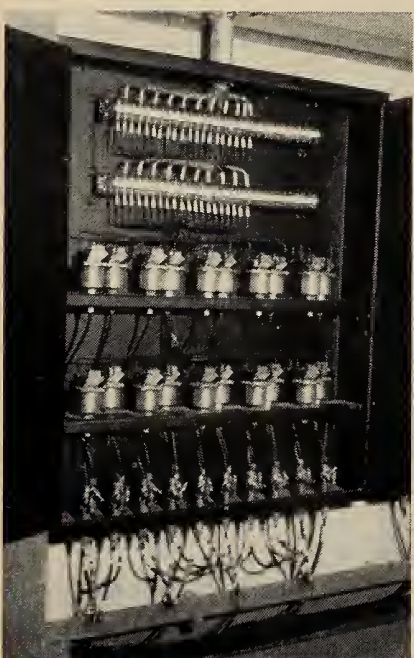


must of necessity be located in the area. The process engineer comes into the picture at this point because he has to ensure that there is sufficient space in each of the buildings to hold these instruments, as well as provide access to them for servicing.

In one case the following satisfactory compromise was reached. Two separate small buildings were provided for housing all the controllers, thereby providing complete protection from the weather and making maintenance a very simple matter. These were neatly mounted in racks inside the buildings as shown in Fig. 3. We also foresaw another major advantage in the use of separate buildings. Due to the nature of our operation all the process buildings were classified as hazardous which meant that explosion proofing must be provided for electrical apparatus. Our electrical interlock and shutdown system necessitated the use of many solenoid valves. However, by locating them in the controller house and providing adequate air purging it was possible to use standard construction. This meant a saving in first cost as well as making maintenance and installation much easier.

For several years now it has been our practice to use bundles of polyethylene tubing for the quarter-inch pneumatic transmission lines. These can be made in bundles of up to nineteen tubes, 1000 ft. in length. A typical plant might contain some forty or fifty of these nineteen-tube bundles on the pipe bridge between the control room and the production area. Each bundle of tubing is purchased with built-in telephone wires. This greatly facilitates checking loops between the control room and process area, by using portable telephone sets. One of the difficulties encountered with this tubing is its considerable expansion and contraction with temperature changes. In order to overcome this problem, expansion loops must be provided at various intervals. One supplier has a design of expansion loop which makes use of special spring assemblies as shown in Fig. 4. From his tables it is a simple matter to calculate the amount of tension required in the spring for the particular temperature at the time of installation. On the pipe bridge in particular it is necessary to protect the polyethylene bundles from welding sparks during the construction period. For this reason the uppermost layer of piping on the bridge is reserved for instrumentation tubing, so that it can be installed at the same time as the process piping without having to worry about the tubes being melted.

Fig. 6.



With the hundreds of pneumatic tubes which require proper installation and connection it is mandatory that a system of numbering and identification be adopted. We have developed a system, now in use on all new projects, which has proven most successful. Tubes which run directly from the control room to the process area use the number system 1-1000. There are also those lines which run entirely within the production area. An example of these might be a local control loop, including a transmitter, valve and recorder controller, the latter possibly mounted on a small panel close to the equipment it is controlling. Such tubes are numbered from 2000-3000. A third set of numbers, 3000-4000, is assigned to those tubes which provide interconnection between units in the control room only. This might be a branch line which connects the measured variable signal to an alarm device, such as a pressure switch. We have found that the contractor's personnel, who are not always familiar with instrumentation, have made fewer errors in installation when using this system, as it requires very little explanation.

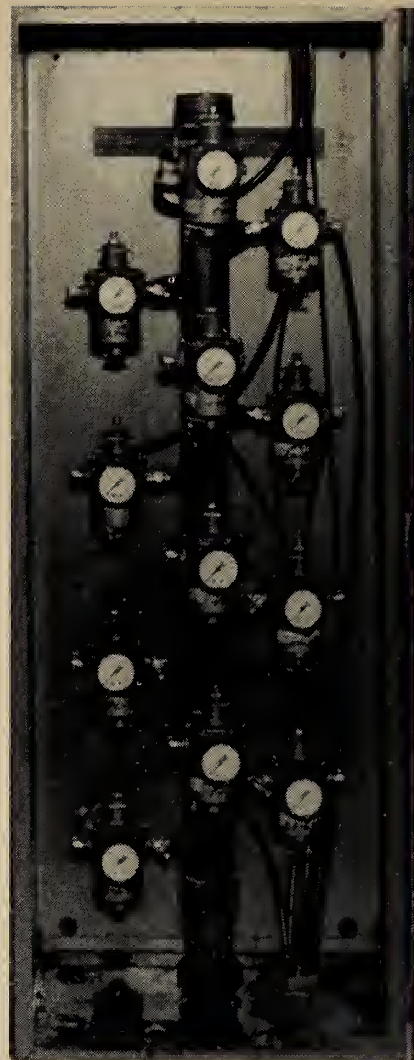


Fig. 5.

It should be pointed out that each transmitter, controller and control valve with positioner requires an air supply as well as a transmission tube. Air is usually provided by a separate compressor and dryer at 100 p.s.i.g. and reduced to 20-25 p.s.i. for each instrument air user. This, then, requires a distribution system similar to that used for the transmission tubing.

Since the plastic tubes in each building are run in conduit it is necessary that a systematic approach be used in order to keep to a minimum the number of small conduits running throughout the building. We therefore provide main junction boxes at strategic locations around the periphery of each building. Another cabinet adjacent to the main junction boxes contains a "hedge-hog" of air supply regulators. Each of these regulators is tagged with the item number of the instrument it is servicing. It now becomes possible to pick up the proper transmission tube and an air supply tube, and run them together in a ½ in. conduit to the proper instrument, (see Fig. 5).

Let us now take a look at some of the considerations necessary in the design of the central control room. Here, apart from the main operating panel, are located many auxiliary controls such as interlock relays, annunciator relay cabinets and pressure switches used for shutdown and alarm purposes. To mount all these units on the control panels themselves presents quite a problem, as the amount of space they take up would make access to the other instruments on the panel rather difficult. Rather than use a standard enclosed pressure switch we purchase a skeleton type, and twenty or thirty of these can be conveniently mounted in a standard electrical box (see Fig. 6). Conventional annunciator relay cabinets can also be installed on the wall adjacent to the pressure switch cabinets thereby making the interconnection between these sets of units very simple.

During the design stage of the plant, the subject of fire protection receives a great deal of study. There is usually some concern that a flash fire might melt the plastic tubing before orderly shutdown could be achieved. This certainly is a problem with bare polyethylene tubing, but can be overcome in several ways. Information is available from the suppliers of the bundled tubing, indicating the length of time the tubes will stand up if subjected to direct flame. This rating depends to some extent on the material used for the protective sheath. The most fire-resistant type, consisting of polyethylene tubes covered with a vinyl sheath, on top of which is a layer of asbestos, followed by a second vinyl sheath, will last approximately five minutes in a fire of 2000°. Compared to other forms of construction, this type of bundle lasts:

- 10 times longer than bare copper tubes.
- 6 1/3 times longer than plastic tubes in a plastic sheath.
- 3 1/2 times longer than copper tubes in a flexible metal wrap.

It is realized that installing this highly-protected material is very costly. Furthermore, nobody can predict with accuracy where this protection will ultimately be required. As a result the following scheme has been adopted in several plants:

Due to their height above ground the main tubing bundles on the pipe bridge are fairly remote from a source of fire, and we therefore use standard polyethylene tubes with a polyethylene sheath. The take-offs from the bridge to the buildings are put in insulated trough. This precaution is taken due to the concentration of tubes at these points. The plastic bundles in buildings are run in conduit, hung in such a manner that insulation can be provided at a later date, if required. At a point close to the instrument the conduit ends in a small 4 in. x 4 in. junction box, and a transition is made to copper tubing so that no bare plastic tubing exists. There are also certain emergency pneumatic valves which are operated directly from the panel. For these valves we install armoured copper bundles from the control room to the buildings. At the entrance to the buildings a transition is made to steel tubing, which runs to the shutdown valves.

The subject of protection of instruments from freezing, using steam tracing and insulation, is worthy of mention. In many plants this is one item which is too often left until the end of the design, and is installed in a rather haphazard fashion. We have tried several protective schemes in the past, such as steel boxes with glass wool lining, various types of blankets and other methods. None of these has been entirely successful. If the insulating material proves too difficult to remove and re-install, after a period of time the maintenance people may not replace it as thoroughly as necessary, and freeze-ups are bound to follow. We have therefore developed several types of insulated boxes using bonded compressed asbestos sheets of half inch and one inch thickness. The sheets are cut to shape in the shop, dipped in water-proofing lacquer, and assembled on an angle iron frame with wing nuts, so that any side of the box can be removed quite easily. On flow transmitter installations the boxes are made large enough for the by-pass manifold to be included in the box. A typical box is shown in Fig. 7.

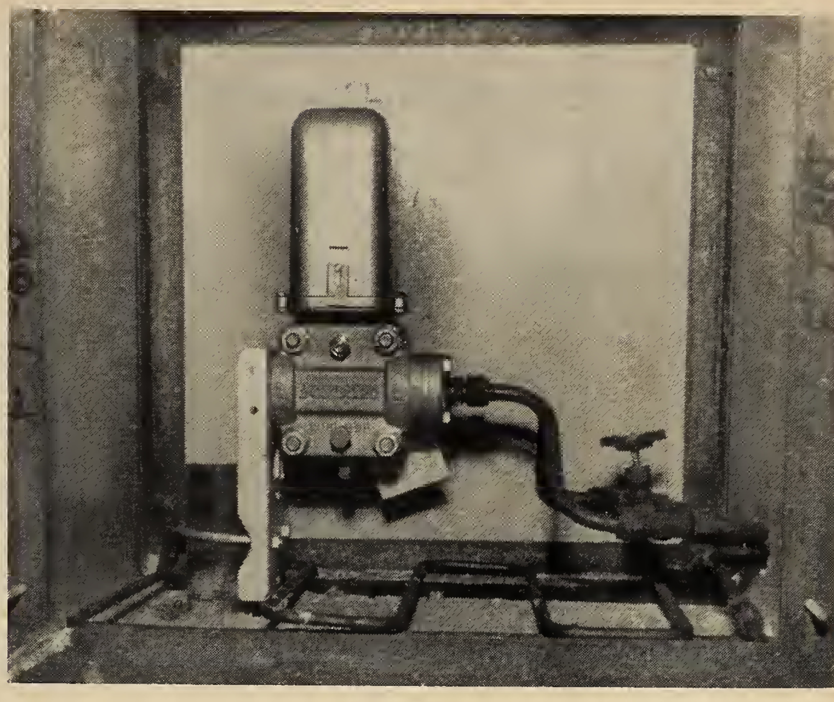


Fig. 7.

In conclusion it should be pointed out that the methods described in the preceding pages are the result of a continuing effort to reduce labour and material costs, as well as to provide a neat installation which is easy to service.

They are far superior to those used five years ago, but will doubtless themselves be modified considerably as new materials and ideas become available and are proven to be economically feasible.

Canadian Developments

In a recent four-way telephone interview set up by the Toronto Daily Star two of Canada's more eminent space scientists, Dr. D. C. Rose, chairman of the Canadian National Committee on Space Research and Dr. Phillip Lapp, chairman of the Canadian Astronautical Society, suggested that Canada's geographical location could be the reason for her playing an important role in the space explorations of the next decade.

Dr. Rose pointed out that Canada's work would be concentrated on the fringes quite close to the earth. Canadian scientists, he said, have already made extensive studies of the Aurora and cosmic rays. Dr. Lapp elaborated on the possibility of Canada's overcoming the obstacle of the Van Allen radiation belt.

Although the nature of this radiation layer is still very little understood, scientists now think that both the inner and outer layers of the Van Allen belt blend into the cosmic ray spectrum. Earlier in this interview Dr. Rose explained that there are bursts of some kind of radiation from the sun which look like low energy cosmic rays, but they occur very irregularly. Dr. Lapp pointed out that scientists are interested in so-called holes in the Van Allen belt. If space vehicles were able to slip through the belt at one of these holes, using a minimum of time and incurring a minimum amount of radiation, this might be the solution to one of the most perplexing problems facing space technologists.

Space Ships and Canadian Industry

Speaking on a panel recently at the University of Toronto's Institute of Aerophysics, on the subject of "Canada's Technical Role in the Space Age", Dr. Lapp expressed the view that Canada would get only a small share of space-age business. He stated that "It has been made fairly clear that within the next decade or more, Canada cannot afford to undertake any large astronautic mission," Dr. Lapp indicated that the natural alternative – industry's looking beyond her national borders for contracts – was more or less ruled out because it was unlikely that another country would want to let such a contract go into foreign hands. "As a result," Dr. Lapp contended, "Canadian industry must be content to play a secondary role in the specialized support field." This would include providing highly specialized novel components for space vehicles.

According to Dr. Lapp, Canadian industry must enlarge its research facilities considerably. Dr. J. J. Green, chief superintendent of the Canadian Armaments Research and Development Establishment at Valcartier, Quebec, also speaking on the panel, said that research work directed specifically toward the region of near space, to a height of about one third the Earth's diameter, would be a sound objective for Canada. Some of the fields which he suggested include: the earth's magnetic field, the nature of the upper atmosphere, nature of the ionosphere, cosmic rays and their origin, and phenomena connected with re-entry into the atmosphere. He also suggested that Canadian research scientists could profitably coordinate their efforts with those in the U.S.

Shock-Resistant Transmitter

A miniature radio transmitter which will work even after colliding with the Moon has been designed by a group of Canadian scientists and successfully tested at the Canadian Armaments Research and Development Establishment at Valcartier, Que. It comprises nine electronic components fitted into a cylinder. To test the mechanism, the transmitter was placed in a projectile and fired off at a speed of 6,000 ft. per second from a smooth-bore gas gun. Though the transmitter batteries were broken off, when new batteries were put in the transmitter was still intact. Dr. G. V. Bull, superintendent of the aerophysics wing of CARDE, concluded that the transmitter could be subjected to up to 100,000 g's upon landing on the Moon and still withstand the shock.

Astronautical Society of Canada Lectures

A series of talks on subjects related to space exploration have been in progress under the aegis of the Astronautical Society of Canada, Montreal, this Fall and Winter. Among them have been discussions of geology and space travel by Professor Vincent Saul of McGill and the possibility of life on other planets by Dr. J. M. Berrill, also of McGill. Professor Saul pointed out that exploration of the Moon and the planets holds great interest for the biologist because of the possibility of life in space, but that for the geologist the prospect of probing other masses represents not *the chance* of discovering mineral and rock formations but *the certainty*. The challenge for the geologist is to be able to discover a variety of geological phenomena that will enable him to better understand the Earth. He anticipates

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• CANADIAN DEVELOPMENTS

(Continued from page 84)

that his methods of exploration and analysis will not be very different from those used on Earth.

Henri T. P. Binet of Montreal presented a paper entitled "Toward Solving the Space Sovereignty Problem" at the Second Colloquium on "The Law of Outer Space" sponsored by the 10th Congress of the International Astronautical Federation in London during September, 1959. Reviewing the history of air law, Mr. Binet pointed out that the provisions of the 1944 Chicago Conference were concerned with flight within the Earth's atmosphere.

In 1958 the General Assembly of the United Nations determined to form an *ad hoc* committee on the peaceful uses of outer space. When the committee met in the summer of 1959, it pointed out that the nations appeared to have accepted the principle of space being freely available for exploration and use by all. They had sent out space vehicles without regard to what particular territory they passed over in their flight through space. The committee agreed that an international agreement on the limits of air space and outer space would be premature at that time.

Since then many people have suggested the establishment of a special United Nations Agency to supervise administration of the new convention to be framed which would be much like the International Civil Aviation Organization set up to administer the 1944 agreement. Others have suggested that ICAO should take on administration of the new space convention. The U.S.S.R. does not belong to ICAO but could be made a member. There is much to recommend combining the administration of laws concerning air space and outer space because there are numerous situations in which space craft operate for a time in their flight as conventional aircraft.

Current Events

Canadian Economy Review for 1959

Canada's gross national product increased by 7% in 1959, while prices rose on the average by 2%. Total national output for the year was up approximately 5%, according to figures recently released by Mr. Gordon Churchill, Minister of Trade and Commerce. Agricultural production was affected by below average harvests of grains and various other crops, but most industries gained substantially and the year's industrial production represents an 8% increase.

Capital spending, public and private, rose slightly in 1959, with commercial, institutional and public investments playing a proportionately larger part than in the previous year. Capital spending in manufacturing amounted to $1.1 billion; housebuilding maintained a high level, though a little lower than in 1958. Housing starts for 1959 were estimated at 140,000 compared to 1958's 165,000.

Recovery in material-producing industries was led mainly by iron and steel which experienced the dual stimulus of rising consumption and restricted American production. Canadian iron and steel output rose two-fifths in 1959. Iron ore output and export have risen 40%. The uranium industry will have a levelling-off period after a very high year in 1959. Within the fuel group, petroleum production and refining increased slightly with rising domestic consumption and higher export volume.

Ontario

Ontario Hydro's Richard L. Hearn plant on the Toronto waterfront, the largest thermal-electric station in Canada, boosted its generating capacity by one-third in January. A 200,000 kw. steam turbo-generator is now feeding power into Ontario Hydro's Southern Ontario System, raising the station's capacity to 800,000 kw. By the end of 1960 the station's output will be at 1,200,000 kw.

Prince Edward Island

According to recent word from Ottawa, considerable progress has been made in the complicated study of a proposal to construct a crossing for the Northumberland Strait between New Brunswick and Prince Edward Island. Nowhere before has a crossing of such length (nine miles) even been contemplated. David J. Walker, Federal Minister of Public Works, has outlined some of the difficulties under study at the present time.

The construction of a causeway would bring about an increase in the range of tides of up to 3 ft. throughout the whole Northumberland Strait. In addition, water levels in the Strait would vary up to 3½ ft. This would result in a differential between opposite sides of the causeway of 7 ft. at mean tides and as much as 10 ft. at high tides.

A full causeway would also result in ice movement being caused only by wind since the currents in the Strait would be stopped. The construction of bridge piers would present a problem because of the velocity of water passing through carrying large ice formations.

Saskatchewan

Construction of the 1959 natural gas program has been completed in Saskatchewan according to J. E. Mollard, chief gas engineer for the Saskatchewan Power Corporation. The last major project of the year was a 40-mile 6-inch transmission line between Alida and Nottingham. The line will transport natural gas from the gasoline plant mid-way between the two communities. This plant and the recovering facilities are now complete and have begun to produce gas. Total production from this source will be between six and seven million cu. ft. per day.

Manitoba

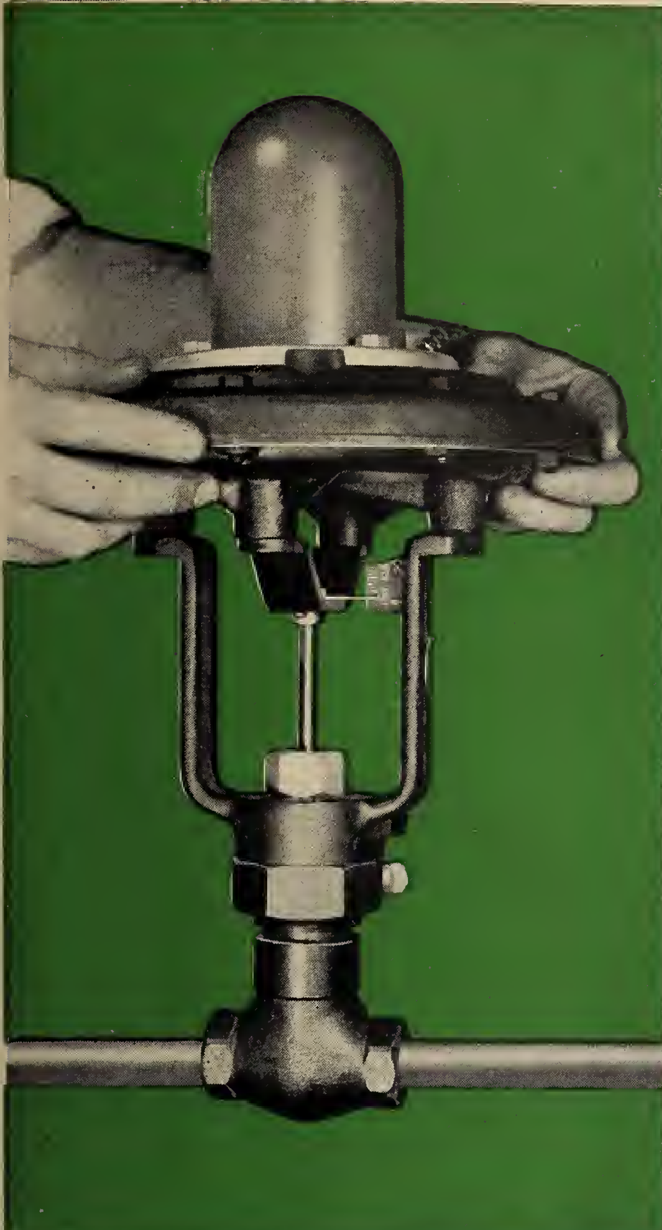
The December issue of the Manitoba Industry and Commerce Bulletin had this to say about an expanded market for Canadian products in the U.K.:

"Generally there is an acknowledged preference on the part of Britons for Canadian food items and consumer products. Some of the products compete succesfully simply by a price or quality advantage. Others are superior to competitive lines in styling, finish, method of packaging, or because a complete range of sizes is readily available. Many items enjoy a tariff preference over foreign competition. The following are some commodities and categories added to those which have been recently freed from import controls: machinery, electrical equipment and apparatus including valves, glass fibre and manufactures, and scientific industrial and optical instruments.

Alberta

Calgary has for a long time been

(Continued on page 88)



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• CANADIAN DEVELOPMENTS

(Continued from page 86)

trying to find an answer to serious frost heave problems. Recently city engineers and workmen laid down an "air mattress" sidewalk on 7th Street SW between 8th and 9th Avenues. They used cardboard "egg crate" forms beneath the concrete to create a cushion of air which would absorb the pressure from frost heave. Each of the crates measures 4 ft. x 2 ft. x 6 in. The concrete was reinforced with steel, but the conventional gravel base was eliminated.

Prior to this Calgary engineers had tried installing wire mesh in a section of sidewalk but, whereas serious cracking was eliminated, the frost heaves persisted. To completely eliminate frost heave it would be necessary to lay a gravel base of greatly increased thickness and the cost of such an operation would be prohibitive.

C.C.A. Construction Equipment Report

Construction equipment will rise in cost during 1960 as a result of a rise in the price of steel and wage increases in the manufacturing industry. Continuing research by equipment manufacturers has resulted in new models and machines designed to increase efficiency. Faster obsolescence of present equipment is inevitable.

Canada's Economy

According to the recent report issued by Gordon Churchill, Minister of Trade and Commerce, the last decade has been one of substantial growth and the period ends, as it began, on a strong expansionary trend. However, the prevailing conditions are quite different from ten years ago. In 1950 and the immediately ensuing years, the key stimulus to growth came from defence preparations and related demands emerging from the Korean crisis and the N.A.T.O. defence effort. At that time, shortages and fears of shortages were prevalent, excessive demand pressures created strains in some segments of the economy and prices rose sharply. By contrast the current expansion is anchored to the more solid foundations of constructive peace time pursuits.

The growing needs of the Canadian people, whether for public facilities or for goods and services, have given the dominant push to the present upward surge of productive activity. During the past year, as the economy continued to move out of the 1957-58 recession, operating levels in most industries have moved closer to capacity and the productive resources of the economy generally have been more fully employed. At the same time, in no area of production has demand become excessive, price changes have been moderate and the general level of prices has increased only slightly.

Production and Employment

Canada's Gross National Product in 1959 has increased by 7 per cent from the level of the preceding year. Prices have risen on the average by 2 per cent. This means that total national output, in physical volume terms, is up by about 5 per cent. Agricultural production in 1959 has been affected by below-average harvests of grains and some oher crops, but most other industries have experienced substantial gains. Industrial production has increased by 8 per cent.

INTERNATIONAL NEWS

Much has been said in the press about the military significance of space flight. Something has been said of its importance in developing communications, weather-forecasting methods, and navigation systems. But Dr. Arthur Kantrowitz, director of the Avco-Everett space laboratory, Cambridge, Mass., has said: "It seems to me that learning to live in space is really the exciting prospect. I regard as the next great landmark in our efforts in space the establishment of manned laboratories in a low orbit near the earth".

Dr. Kantrowitz has also made the point that although the scientific probes being carried on can have either military or civilian application, the essential findings remain the same. We find Dr. Krantrowitz, who has said that the greatest challenge in the space probe is to establish life beyond the earth, devoting himself to magnetohydrodynamics and, most specifically, the problem of re-entry heating of nose cones.

This work began in 1954 when Dr. Kantrowitz, then a professor of gas dynamics and engineering physics at Cornell University, suggested that a shock tube could be set up in the laboratory to simulate re-entry conditions. Not long afterward he was asked to set up Avco's new research laboratory at Everett, Mass. In six months he had substantial data on stagnation point heating under re-entry conditions from a special shock tube over 100 ft. long which he had built. Gas, fired through the tube, simulated flight speeds up to 18,000 m.p.h. Later an arc wind tunnel, using electric arcs to heat air to very high temperatures, replaced the shock tube.

In late 1956 Dr. Kantrowitz and his team made two important discoveries: At speeds up to 18,000 m.p.h. up to 10 kw. per sq. cm. heat would be transferred to an object during re-entry; the best resistance to these conditions could be had from ablating materials.

At present Dr. Kantrowitz is working on high- and low-temperature magnetohydrodynamics. The high temperature studies are concerned with fusion reactor applications, the nature of the Van Allen radiation belt, and propulsion of space vehicles using nuclear and solar energy. The low temperature work is on the possibility of generating electric power from gases less than 10,000° K. which have been heated by uranium fission.

British Design Shock Tube

The British have recently announced that scientists at the National Physical Laboratory are constructing a hypersonic shock tube to simulate the conditions of missile flight at speeds up to 18,000 m.p.h. Like the Kantrowitz tube, it is based on the principle of the sudden release of pressurized gas. The required aerodynamic performance of the shock tube calls for high "driver" pressure in the chamber of the shock tunnel. About one cu. ft. of hydrogen, at a pressure a thousand times greater than the atmosphere, is released by rupturing the diaphragm into the working section of the tube. A dump tank, fitted downstream of the working section, ensures that the final equalization pressure in the apparatus does not exceed five atmospheres.

ASME Talks on Space Flight

The American Society of Mechanical Engineers, meeting in Atlantic City, New Jersey in early December considered a number of space flight problems. Ezra S. Krendel, head of the engineering psychology branch of the Franklin Institute, Philadelphia suggested that rocket ship pilots may find themselves cranking and pedalling — rather than pushing buttons. A human passenger in a space ship may have to supply some of his own power in order to save the weight and space needed for other power sources such as batteries, according to Mr. Krendel. At the same meeting a number of papers were presented on the physiological effects of space flight. The U.S. Navy's Aviation Medical Laboratory at Johnsville, Penn., reported a series of experiments indicating that the ability of men to resist acceleration decreases as the temperature goes up. A paper written by a physician, however, pointed out that properly designed space suits could cut the effect on humans of the high temperatures produced as the space ship leaves and re-enters the atmosphere.

Cornell University Space Study Center

Cornell University has announced plans to set up the first large university-sponsored center for radiophysics and space research. Professor Thomas Gold, internationally recognized British cosmologist, will direct the new center and Professor Henry G. Booker, known for his theoretical research of electromagnetism and radio propagation, will serve as associate director. The Cornell University Center for Radiophysics and Space Research will have the world's largest and most powerful radar at its disposal, according to an official report from the university. The giant radar, composed of a 1,000 ft. wide dish and 600 ft. high tripod supporting the feed antenna, will send signals at a power peak of 2.5 million watts and a frequency near 420 megacycles. Located in Puerto Rico, the radar should permit staff members of the center to study the under-surface of the planet Jupiter, about 400,000,000 miles away when closest to the Earth.

(Continued on page 91)

8,000 bbl. sphere, 44 3" diameter, 50

• INTERNATIONAL NEWS

(Continued from page 89)

The record distance for a radar beam reaching out into space and being recorded on earth is credited to Jodrell Bank, England, where a signal has been bounced off Venus.

In addition to the radar colossus which the Department of Defense is financing for the Cornell space research unit, two other new installations will permit extensive research —a radio astronomy receiving apparatus to be built south of Ithaca, New York and a transmitting station, on University property.

Plastics in Space Ships

Plastics have come to play a large part in rocket design research. Reinforced plastics offer a number of attractive characteristics including a good strength-to-weight ratio, thermal and electronic insulating qualities and usefulness from the logistics point of view. They have also been found good as ablating insulations for rocket nozzles and aerodynamic surfaces where flame temperatures exceed the service temperature of any available metals and refractories.

W. E. Zisch, vice president and general manager of the Aerojet General Corporation, recently pointed out that whereas 4% of his company's expenditures this year were for plastics activities, he expected that five years from now the figure would be closer to 20%. He emphasized than increased efforts in education on plastics is essential to their emergence as an important material in rocket and missile construction. Centres on quality control and an industry-wide standardization of materials will also be necessary, if plastics are to have any future in the space field.

Fibreglass for Atlas

The combustion chamber of the U.S.'s Atlas is now being wrapped with fibreglass threads rather than the conventional steel restraining bands. This innovation represents a cost saving of 25% and approximately a 25% weight reduction on the Atlas engines.

Space Paint

A paint which will resist the extreme heat of re-entry into the Earth's atmosphere has been developed by a Missouri company It works by a process of bulimation, the transition of a solid into vapour without an intervening liquid stage.

Midget Camera for Missiles

At Woomera, Australia, scientists have developed a camera hardly bigger than a spool of cotton to be mounted in British missiles for recording details of target interceptions at test firings. "Wreciss" (Weapons Research Establishment camera interception single shot) is virtually indestructible.

Swedes Design H-Power Tube

A new apparatus designed to study the behavior of hydrogen plasma when accelerated in a magnetic field is being tested at the Physical Institute of Upsala University, Stockholm. It is hoped that this may be a step towards hydrogen-power propelled

space rockets. It has been possible to attain ion speeds in the experimental unit which, converted into thermal movement, correspond to one million degrees C. The apparatus consists of a 60 cm. tube with an inner diameter of 12 cm. The heavy electric impulse fed into one end of the tube causes the induction of a counter-current in the hydrogen plasma. The two currents, repelling each other, cause the plasma to rush through the tube, in the shape of a ring, at a speed of about 60 miles per second. According to experts a similar unit, considerably enlarged, might be used for rockets of the future. The exhaust speed of the plasma is 30 to 40 times greater than that of any known chemical rocket fuel. Scientists must still discover a means of energizing on board the rocket the heavy electric impulses required for accelerating the plasma.

U.S. develops H-power

A hydrogen pump which makes possible hydrogen-fueled space engines with up to 500,000 lbs. thrust has been designed by Aerojet. James H. Madden, head of the Engine Reliability Department at Aerojet's Liquid Rocket Plant, has stated that with a cluster of from seven to ten liquid fueled rocket engines, each with a thrust of from 100,000 to 200,000 lbs., the best immediate booster propulsion system for manned space vehicles could be made available. Authorities at Aerojet consider this new hydrogen pump the key to production of powerplants with up to 10,000,000 lbs. thrust.

The output of each engine in the cluster, as Madden described it, would be such as to compensate for one or even two engines if they were to give out in flight. The remaining engines in emergency would increase their thrust level to a point where the total thrust was the same as that provided when all engines were operating.

U.S. Reactor for Space Ships

A 220 lb. nuclear reactor has been designed by the Atomic Energy Commission to supply electrical power for advanced space vehicles. It is unquestionably the smallest reactor to be built this side of the Iron Curtain and may be the smallest in the world. It will generate 3 kw. of power for long periods of time.

British Satellite

By 1961 British scientists hope to have their own space satellite circling the earth 300 miles up. A radio transmitter and 150 lbs. of equipment should be housed in the satellite. It is expected that an American three-stage rocket using solid fuel will put the station in orbit and that the launching will take place in either Virginia or California. Cost of research and equipment for the satellite is estimated at $1,200,000 to $2,400,000.

French Missile Plans

An intermediate range ballistic missile developed with U.S. technical aid and armed with a French warhead will be the mainstay of the French striking force. The I.R.B.M., according to present plans, will be in the 1,500 to 2,500 mile range and will run on solid fuel. Responsibility for developing France's I.R.B.M. will rest with the Societe pour les Etudes et Realisation des Engines Ballistiques (S.E.R.E.B.), a new combine set up several months ago. It comprises most of the French aircraft companies and several government agencies.

Japanese receive Sidewinders

Fourteen Sidewinder air-to-air missiles were delivered by the U.S. to the Japanese experimental unit at Gifu in December. Ninety more are en route. These were ordered by Japan's Air Self Defence Force.

The Japanese Maritime Self-Defence Force has set up a three-year program for building a missile destroyer of 2500 tons displacement.

Soviet Missile Bases Out-Number NATO's

The Institute of Strategic Studies, London, reports that Soviet missile bases outnumber NATO's 100 to 7. The Soviet missile base network is commanded by a single Engineer-General who controls the production of rockets, guided missiles and nuclear weapons. He is also in charge of testing.

U.S. Fellowships for Space Study

Daniel and Florence Guggenheim Fellowships for 1960-61 graduate study in space flight, rockets, jet propulsion and flight structures will allow up to 18 American and Canadian students to study at the Daniel and Florence Guggenheim Jet Propulsion Centers at Princeton University, California Institute of Technology and the Florence Guggenheim Institute of Flight Structures at Columbia University, New York. The fellowships provide tuition and a stipend of $1,500 to $2,000 depending on the stage of advancement of the student.

Fellowships are open to qualified science and engineering students resident in either the U.S. or Canada who intend to make a career in rockets, jet propulsion, flight structures or astronautics. Applications are due by March 1, 1960.

IXth International Astronautical Congress

Proceedings have been published from the IXth International Astronautical Congress held in Amsterdam in 1958. They may be obtained through the American Astronautical Society, 516 Fifth Avenue, New York 36, N.Y. Sessions included: Upper Atmosphere Research; Physics of Space Flight; Astronautical Engineering; Propulsion; Artificial Satellites; and Space Biology and Medicine.

Current Events

Finland Requests Uranium

The Finnish government has requested the International Atomic Energy Agency to supply enriched uranium for its Triga Mark II reactor. This is the first formal request for fissionable materials which the International Agency has received.

The Finnish reactor, to be completed before the end of 1960, will require uranium enriched up to 20% in the isotope U-235. An estimated 2.6 kg. of the isotope will be required. Finland has also requested assistance in fabricating the enriched uranium into fuel elements for the Triga reactor which needs 60 elements for one complete loading. Approximately ten spare fuel items are also called for, consisting of an alloy of enriched uranium and sirconium hydride clad with aluminum.

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Elections and Transfers, for February, 1959, are listed on page 98 of this issue.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on September 12, 1959.

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Junior: R. H. B. Hebbert, Kingston; D. C. Stephenson, Niagara Falls; R. B. White, Montreal.

Affiliate: M. L. Smith, Hamilton.

Junior to Member: I. J. Billington, Toronto; R. A. Butts, Montreal; C. M. Cotton, Fort William; A. Curran, Montreal; R. A. DeBou, Vancouver; L. L. Denoncourt, Montreal; J. S. Flavelle, Pembroke; R. F. Frank, Montreal; E. A. Gauthier, Montreal; H. R. W. Marsh, England; L. D. McKenna, Ottawa; H. R. Pelle, Burlington; R. R. Schieck, Thorold; R. F. Shapcotte, Vancouver; J. Sidler, Montreal; G. S. Sugiyama, Winnipeg; C. L. Wild, England; D. T. Wright, Waterloo.

Student to Member: W. A. Scholz, Montreal.

Student to Junior: R. S. Butler, St. John's; E. B. Smythe, Toronto.

STUDENTS ADMITTED

Ecole Polytechnique: R. Aquin, R. Aubin, R. Bibeau, A. Brasseur, K. Chounramany, G. Corbeil, G. Daigneault, A. Desjardins, J. F. Desmarais, G. Dubuc, A. Dugal, C. Durand, M. Fournier, A. Gagnon, E. Gervais, D. Gill, P. Giroux, J. J. J. Gravel, N. Hebert, A. Hennico, H. Hudon, F. Jerabek, E. L. Juneau, G. Lacroix, J. C. Lalancette, M. D. Lalanne, J. Lamarche, M. Langlois, J. G. Latremouille, P. Lavallee, A. Lavoie, G. Lecours, C. Leduc, J. Lemelin, J. J. Leveille, M. Limoges, E. G. Longpre, J. G. Lorrain, M. Maccaferri, P. Marchand, C. Murray, N. Payette, G. Piche, A. Pilon, J. Rivet, H. Sanith, J. G. Sicotte, K. Tainglim, G. Turcotte.

McGill University: J. E. Michalski, R. A. F. Montoute, I. Spinner, D. P. Temponeras, B. Ziegler.

University of Toronto: C. Lischkoff, K. Lum, D. B. Munro, M. D. V. Williams.

Ontario Agricultural College: J. L. Barlow, J. E. Kudlac.

University of Alberta: D. R. Shepherd.

Nova Scotia Technical College: J. L. Coughlan.

Mount Allison University: G. D. Spencer.

B. G. Porter, B.A.Sc. (Civ.), University of Toronto 1959; F. Williamson, B.Sc. (Mining Engrg.), University of Alberta 1959; R. K. Wood, B.Eng. (Chem.), University of Saskatchewan 1958; J. G. Simoneau, Student, Corporation of Professional Engineers of Quebec; D. M. P. Scott, G., I.M.E., 1958.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective:

ALBERTA

Student to Junior: A. Willumsen.

SASKATCHEWAN

Members: J. Ferrara, G. F. Fleming, R. J. McIntyre, B. W. Mickleborough, J. Nikolaychuk; **Juniors:** W. A. Derry, A. D. Newsham, G. M. Parker, C. A. Pegg; **Student:** A. J. Gallinger; **Junior to Member:** T. E. Huta; **Student to Member:** M. Gumprich; **Student to Junior:** M. Feldman, D. A. Smith, A. F. Lukey.

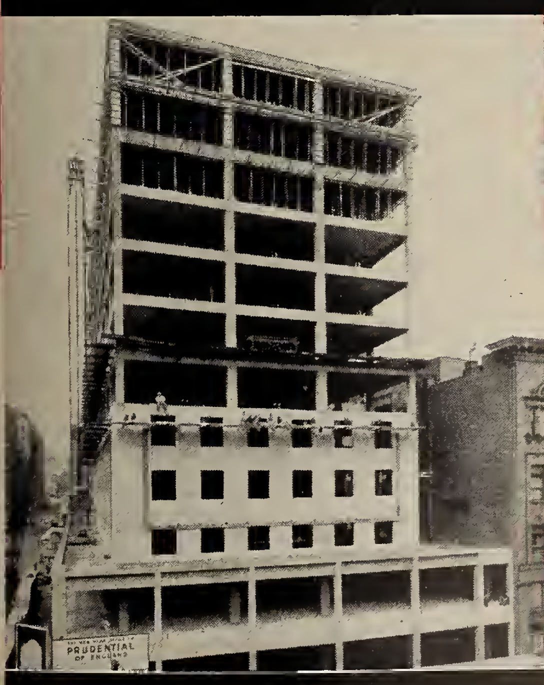
NOVA SCOTIA

Junior to Member: F. J. Abbass, C. J. De Lory, J. A. Waugh.

FEBRUARY 9 1959

MARCH 10 1959

APRIL 9 1959



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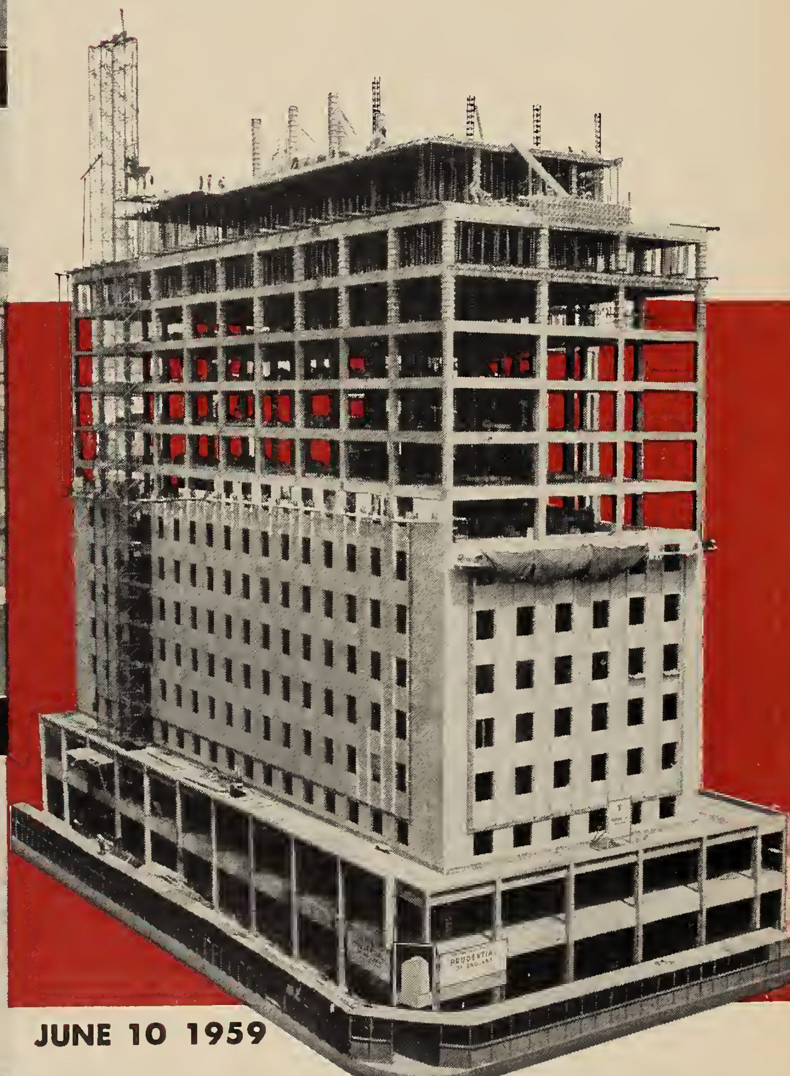


JUNE 10 1959

Personals

Gerald B. Williams, M.E.I.C. (Manitoba '35), chief engineer of the Department of Public Works' Development Engineering Branch (Ottawa), has been appointed assistant deputy minister (technical) for the Department.

G. B. Williams, M.E.I.C.

F. L. Peckover, M.E.I.C.

F. Lionel Peckover, M.E.I.C. (Toronto '44), in charge of the soil engineering section, St. Lawrence Seaway Authority until May, 1959, is now employed by the Canadian National Railways as engineer of soils and foundations, Montreal.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

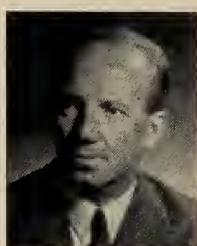
Address all information to: *The Engineering Journal*, Editorial, 2050 Mansfield Street, Montreal, Que.

Morley G. Taylor, M.E.I.C., (Nova Scotia Technical '27) has been made president and chief operations officer of International Power Company Limited. He succeeds Frederick Krug, M.E.I.C., who becomes chairman of the board and continues as chief executive of the company.

Dwight S. Simmons, M.E.I.C., (Queen's '32), general manager of manufacturing for Imperial Oil, is the new president of the Association of Professional Engineers of Ontario.

F. T. Gale, M.E.I.C., (Alberta '35) has been appointed assistant general manager of Calgary Power Ltd. He will continue in his present capacity as vice-president of Farm Electric Services Ltd., as well.

R. L. Raikes, M.E.I.C. (London University, England '32) has been appointed a director of Lewis, Lane and Company Ltd., Consulting Civil Engineers, Sudbury.



R. L. Raikes, M.E.I.C.

G. C. Widdup, M.E.I.C.

G. C. Widdup, M.E.I.C. Manchester '43) has been made chief engineer of Canadian Schenley Ltd. with headquarters in Valleyfield, Que.

Lawrence C. Sentance, M.E.I.C. (Saskatchewan '35), manager of the defence apparatus division and atomic energy division, Canadian Westinghouse Company, has been elected first vice-president of the APEO.

E. H. Brooke, M.E.I.C. (Alberta '42), chief engineer of Texaco Canada Limited, has been appointed to direct the company's new central Executive Offices Engineering Department in Montreal.

G. H. Crase Jr., M.E.I.C. (Toronto '42) has been appointed Ontario District Sales Manager of Horton Steel Works Limited, Toronto.

R. R. Jackson, M.E.I.C. (Alberta '44) has been appointed vice-president and general manager of Ontario operations of Mussens Canada Ltd., Toronto.

Allison F. Mosher, M.E.I.C. (British Columbia '44) has been appointed to establish the Ontario branch of Philip French Sales Ltd. He will be located in Toronto.

Michael Shayna, M.E.I.C. (Saskatchewan '51) has recently taken up the post of assistant plant superintendent of Western Clay Products Limited and is in charge of their research and development.

W. J. Smith, JR.E.I.C. (Manitoba '51) has been appointed chairman of the County Engineers' Advisory Committee. He is also the 1960 president of the County Engineer's Association of Ontario.

T. R. Marien, M.E.I.C. (McGill '52) has been named a director of the Pentagon Construction (1959) Co. Ltd.

Allan G. Moffatt, M.E.I.C. (Toronto '44) was recently elected director of Haddin, Davis & Brown (Manitoba) Ltd.

A. G. Moffatt, M.E.I.C.

A. A. Albert, JR.E.I.C.

Auguste A. Albert, JR.E.I.C. (New Brunswick '50) is the new secretary and engineering director of Dimock Construction Inc., New Richmond, Que. with a branch office at Rimouski.

W. J. Mann, JR.E.I.C. (Manitoba '54) has been made general manager of Canadian Curtiss-Wright Ltd.

William J. Carson, JR.E.I.C. (Nova Scotia Technical '56) has been made executive assistant of Hewitt Equipment Ltd., Montreal. He was formerly general sales manager.

NEWS OF THE BRANCHES

Brockville

J. R. Eastwood, M.E.I.C., *Correspondent*

Dean Mordell of McGill University addressed the December 7 meeting on the importance of engineering to food, energy, shelter and transportation. Scientific achievements would not be possible without the assistance of engineers, he pointed out, hence the betterment of living conditions is dependent on the profession. Engineering has played a large part of recent years in projects in underdeveloped countries only a few of which have been irrigation, conversion of salt water into fresh, and the development of new sources of energy such as the sun and sea tides.

Calgary

Herbert Bailey, M.E.I.C., *Correspondent*

Calgary E.I.C. members heard Mr. Israel Switzer, computer applications analyst with the McBee Company, discuss the importance of electronic computers to engineering on December 1. He stated that engineers were slower than some other groups in adopting computers. Research teams working on ballistics and space vehicles, he pointed out, have adopted computers quite universally for their work. Mr. Switzer strongly recommended that professional societies and university extension departments make an effort to train engineers in the use of computers.

Cape Breton

H. M. Aspinall, M.E.I.C., *Correspondent*

On December 9 the Cape Breton Branch held their Annual Business Meeting in the Officers' Mess, Victoria Park, Sydney. The meeting was presided over by W. L. Dodson, branch chairman. The secretary, treasurer, program convenor and student guidance convenor presented their reports on the year's activities and new officers were elected.

Edmonton

George Hodge, M.E.I.C., *Correspondent*

Dr. R. M. Hardy, a member of the Borden energy commission, addressed branch members on Nevember 27, stating that a pipeline to carry Alberta's crude oil to Montreal would be advantageous to the Canadian economy. In order to make the proposed pipeline feasible, Dr. Hardy, former dean of engineering at the University of Alberta, pointed out that the federal government would have to impose restrictions on the import of foreign crude now being processed in the Montreal refining area.

Fredericton

John Burrows, JR.E.I.C., *Correspondent*

A panel discussion, "Are engineers professional or technical advisers?", was held at The Lord Beaverbrook Hotel on December 14. Mr. R. D. Neill of the N.B.E.P.C. acted as moderator and Mr. J. L. Feeney, commissioner of the N.B.E.P.C., and Mr Stanley B. Cassidy, electrical contractor, were panel members.

In support of the professional status of the engineer, the members of the panel remarked that engineering in general promotes works which are to the benefit of mankind. They pointed out that those active in this field pursue an occupation requiring a varied and lengthy technical education as well as much practical experience. They are responsible for, and much concerned with, the performance of engineering structures which they design.

It was felt that ideally engineers should be freely engaged in individual activity. Although this is not possible for all engineers, those on salary should make an effort to retain their identity by gaining recognition in their field of specialization and accepting responsibility. Industrial engineers were cited as those frequently included in labour organizations of a type not usually beneficial to professional status.

Halifax

W. J. Phillips, M.E.I.C., *Correspondent*

"The Digital Computer—An Engineering Tool" was the subject of a talk by Messrs D. G. Brown and K. F. Duggan on November 24. More than 70 members were in attendance. The men reviewed the development of both analog and digital computers and discussed the problems of programming with particular reference to a demonstrator computer lent by Saint Mary's University.

Kootenay

I. Waterlow, JR.E.I.C., *Correspondent*

Mr. Gordon Turner, research engineer with Consolidated Mining and Smelting, gave a talk on semi-conductors December 8. He discussed their formation and electrical properties in relation to temperature and current available.

Niagara

E. C. Little, M.E.I.C., *Correspondent*

Some 45 members met at the Lenord Hotel, St. Catharines, for the December meeting. Mr. E. W. Haack, applied science representative for IBM, described the analog computer and showed how it could be used as an engineering tool in the design of power houses, transmission lines, transformers and generators.

Ottawa

Philip Ristow, JR.E.I.C., *Correspondent*

On November 5, Mr. N. B. Hutcheon, assistant research director of the Division of Building Research, National Research Council, spoke to members on problems of development in India. He recently returned from a three-month technical mission to assist India's building research department. He pointed out that the low cost of labour discouraged the adoption of modern mechanisms and that the quality of products in India was highly variable.

Peterborough

R. M. Allemang, M.E.I.C., *Correspondent*

Dr. Philip A. Lapp, president of the Canadian Astronautical Society and senior project engineer with DeHavilland Aircraft, spoke at a dinner meeting in December on "Space Vehicle Engineering". Dr. Lapp concentrated on the guidance and control functions in missiles and outlined the limitations and possibilities of the various propulsion methods. He concluded with a description of the major problems yet unsolved in space vehicle design.

Sault Ste. Marie

R. L. Wimperis, JR.E.I.C., *Correspondent*

Mr. A. Joynson, of Proctor & Redfern Consulting Engineers, was guest speaker at the November 27 meeting. He stated that government action has brought about the purification of water. Both municipalities and industries are guilty of water contamination and will need to take a responsible role in getting rid of it, he stated. Mr. Joynson discussed plans for the sewage disposal system for Sault Ste. Marie and the surrounding area.

Sudbury

Archie B. Platt, JR.E.I.C., *Correspondent*

Over 30 members and guests attended the December meeting held in the Granite Club. Dr. T. Hugill of Canadian Liquid Air spoke on tonnage oxygen plants, covering the ferrous and non-ferrous industries. Of particular interest was his description of the low pressure air separation plant at Copper Cliff, Ont. Mr. Hugill also described the units used in petroleum refineries to produce ammonia from refinery "off" gases and the double cycle air separation units mainly used in the steel industry for oxygen process steel furnaces.

News of Other Societies

American Astronautical Society

The Sixth Annual Meeting of the A.A.S., held in New York City, January 18-21, included sessions on Space Communications, Propulsion, Guidance and Control, Space Medicine and Astrobiology, Space Flight Mechanics, Space Vehicle Design, Applications of Astronautical Systems, and Space Physics. The guest lecture in the Astronautical Sciences was delivered by George P. Sutton, chief scientist, Advanced Research Projects Agency.

The Society of the Plastics Industry

Over 1,000 persons attended the Fifteenth Annual Reinforced Plastics Division Conference of The Society of the Plastics Industry in Chicago, February 2-4. Under discussion were: radomes, missiles, decorative laminates, structural panels, submarine superstructures, underwater weapons, preimpregnated fabrics, joints on concrete pipe, and reinforced plastic pipe.

The Plastic Bottle & Tube Manufacturers' Institute will be held in New Orleans, La. February 16 and 17, while the Seventeenth Annual SPI Western Section Conference will take place on April 7 and 8 in Palm Springs, Calif.

Soil Mechanics and Foundations Division, American Society of Civil Engineers

A Research Conference on Shear Strength of Cohesive Soils is to be held at the University of Colorado, Boulder, June 13-17. Engineers interested in attending the conference or obtaining a copy of the proceedings should contact Dr. J. W. Hilf, Secretary, Task Committee on Shear Strength of Soils, ASCE, Bureau of Reclamation, Building 53, Denver Federal Center, Denver 25, Colo.

Instrument Society of America

The Sixth Annual Symposium on Instrumental Methods of Analysis is to be sponsored by the Montreal Section of I.S.A. in co-operation with the Chemical Engineering Section of the Chemical Institute of Canada. It will be held at the Queen Elizabeth Hotel, Montreal, June 1-3. Papers are required in the following fields of analysis instrumentation: Medical, Pulp and Paper, Food and Tobacco, Petrochemical, and Metallurgical. Intent to present papers must be mailed by February 28, 1960, to Mr. J. J. Gravel, Technical Publicity Chairman, Pulp and Paper Research Institute, 3420 University Street, Montreal 2.

Coming Events

The Chemical Institute of Canada

February 18—Protective Coatings Division Conference, Toronto.
February 19—Protective Coatings Division Conference, Montreal.

McGill University, Faculty of Engineering

Symposium on Flight—January 21 to March 10.
February 18—"Polar and Mid-Latitude Navigation", K. R. Greenway, R.C.A.F.
February 25—"Flight Propulsion", D. L. Mordell, McGill
March 3 —"The Evolution of Aircraft Structures", A. R. Edis, McGill
March 10 —"Flight into Space", W. F. Campbell, National Aeronautical Establishment.

Toronto Quality Control Society

March 5 —Seventh All-Day Forum, University of Toronto
May 24-26 —14th Annual Convention and Exhibition of American Society of Quality Control, San Francisco.

University of Florida, Mechanical Engineering Department

March 7- 8—Heat Transfer Symposium

Institute of the Aeronautical Sciences

March 10-11—Flight Propulsion Meeting (classified), Cleveland.
April 20-22 —Manned Space Stations Symposium, Los Angeles.

Instrument Society of America

April 3- 8 —6th Nuclear Conference, New York
April 5- 7 —3rd National ISA Chemical and Petroleum Instrumentation Symposium, Rochester, N.Y.

"Expomat" Exhibitions

March 17-27—International Construction Exhibition, Paris
May 19-29 —International Public Works and Building Equipment Exhibition, Paris, France.

American Management Association

June 13-15 —Workshops on Research and Engineering Administration, Toronto.

E. I. C.

ANNUAL MEETING

WINNIPEG

MAY 24-27

NEWS OF THE

Associations and Corporation

Ontario Professional Engineers Hear Panel on Enlightened Administration of Engineering Staff

A NUMBER OF IDEAS concerning the relationship between engineer manager and technical engineer were introduced by panel members at the annual meeting of the Association of Professional Engineers of Ontario, in Toronto, January 23. On the panel were: L. R. Campbell, Bell Telephone; Henry S. Dawson, Canadian General Electric; R. G. Teasdale, Atlas Steel; R. W. Dunlop, M.E.I.C., Imperial Oil, all in management.

Mr. Campbell described the most important element in the implementation of management philosophy as recognition of individual contribution.

Mr. Dawson felt that business factors and professional productivity were most important in proper administration of engineering staff.

Mr. Teasdale stressed the need for development of the individual. He supported a program founded on the belief that it must help the participant to learn to use himself.

Mr. Dunlop expressed the relationship between people in an organization as most important in carrying out effective programs.

The second panel of Association members contributed to the discussion by interjecting some of the thinking of professional engineers who see the problem from a different vantage point as essentially non-management engineers. It included: C. E. Rickards, Northern Electric; D. T. Bath, M.E.I.C., Canadian General Electric; K. B. Shirazee, Canadian National Telegraphs; and R. M. Sachs, Orenda Engines.

R. W. Diamond, Hon. M.E.I.C. (left) is presented with an engraved replica of the Honorary Life Membership certificate which he was awarded by the Association of Professional Engineers of B.C. last year. Making the presentation is Past-President R. E. Wilkins, M.E.I.C. (right), while the new president, H. P. J. Moorehead, looks on.

Mr. Rickards advanced several points which might bring about better relations between management and engineers: the termination of automatic progression salary payments and the adjustment of the professional engineer's salary to his own individual effort; institution by industry of a trial period of employment for professional engineers; the surrender on the part of professional engineers of protection under formal bargaining agreements and a willingness to depend upon their own abilities for guarantee of working conditions and remuneration.

Mr. Bath felt that better communication between employee and employer was the key to a better relationship. He said professional engineers feel a need for mutual confidence with the employer.

Mr. Shirazee said the professional engineer wants social approval of his work, and self-respect results. He also wants to be used to his highest capacity.

Mr. Sachs pointed out that there was a division in the engineering profession with the two groups formed—one group which became managers and the other which concerned itself with purely technical engineering. "The manager group doesn't often understand the technical group and vice versa," he stated.

Theoretical Courses Gaining in Number

A greater emphasis on advanced theoretical courses and mathematics is the current trend in engineering education, Prof. V. G. Smith, of the University of Toronto, told the Association of Professional Engineers of Ontario at their annual meeting.

Professor Smith, who is on the university's electrical engineering faculty, said the trend is to eliminate some of the practical courses from engineering curricula in favour of more advanced theoretical courses and mathematics. He said this trend is reflected by a new syllabus of examinations, approved by the Canadian Council of Professional Engineers, which is being brought into use.

(Continued on page 126)

Now Allis-Chalmers brings its 85 years of pump experience to the short-coupled vertical turbine-type field. This addition not only rounds out industry's most complete single source for pump installations, it offers many advantages wherever liquids are to be pumped. Standard sizes for heads up to 400 ft or more, and capacities ranging from 20 to 8000 gpm.

Pressures can be increased by simply adding a stage to the existing pump without increasing space requirements. Equipment and installation costs are low. Motor and discharge nozzle are supported by a single, small foundation. There's no need for suction pipe, interlock controls or priming equipment. Allis-Chalmers hollow-shaft motors remove the danger of open couplings.

Many advantages — Self-priming • eliminate suction piping costs • save space, motor support and discharge nozzle are integral • low first cost • increase pressure easily • operate quietly • low maintenance with one stuffing box • no motor flooding.

Many applications — Water systems, irrigation, condenser systems, bilge and sump service, dry docks, fire equipment, filter washing, recirculation, transfer pumping, process pumping, cooling condensers and diesel engine jackets, air conditioning, caisson and mine dewatering, general-purpose pumping.

Allis-Chalmers pump experts will be happy to tell you about this new addition to an outstanding line. For complete information, contact your nearest CA-C Sales Office or write direct to Canadian Allis-Chalmers Limited, P.O. Box 37, Montreal, Quebec.

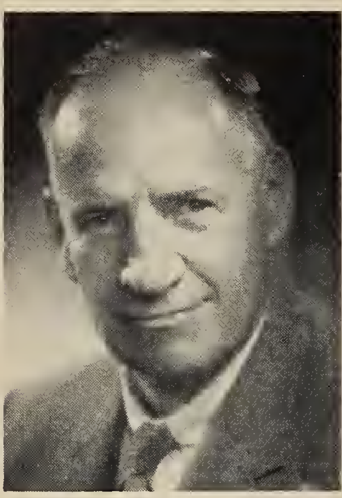
CANADIAN ALLIS-CHALMERS

59-P-8

Dr. Convey Addresses B.C. Meeting

One of the highlights of the annual meeting of the Association of Professional Engineers of British Columbia in December was an address by Dr. John Convey, Director of Mines and Technical Surveys in Ottawa.

Dr. Convey explained that the international ban on nuclear experiments stands in the way of applying atomic energy to the extraction of oil from the Athabasca tar sands. Many other methods have been tried without success, he said, but there is evidence that the shock and heat of nuclear explosives can separate the oil from sand and allow it to be pumped to the surface. Nine separate expcriments in the U.S. have proved that nuclear explosives can be safely discharged underground, and the dangerous radioactive elements contained in a great underground slage bubble, Dr. Convey reported.



Dwight S. Simmons, M.E.I.C.

Dwight S. Simmons President of Ontario Association

The Association of Professional Engineers of Ontario has elected Dwight S. Simmons, M.E.I.C., of Toronto, as its 1960 president. He succeeds A. W. F. McQueen, of Niagara Falls.

Mr. Simmons is general manager of manufacturing for Imperial Oil. A native of Sarnia, Ontario, he graduated from Queen's in mechanical engineering in 1932 and has been with Imperial Oil since then. He has served on the A.P.E.O.'s Executive Council for five years and last year was the Association vice-president.

Elected 1st vice-president for 1960 is Lawrence C. Sentance, M.E.I.C., of Hamilton. The 2nd vice-president is Robert L. Hicks, M.E.I.C., Toronto.

A.P.E.O. Awards Gold Medal

The A.P.E.O. Gold Medal Award, presented annually to the two engineering students who have graduated with the highest standing from the University of Toronto and Queen's University, has been given to John R. Luke, of Toronto, a graduate in mechanical engineering from the U. of T., and Raymond J. Buhr, of Coburg, who graduated from Queen's in engineering physics. The awards include a $50 cheque to be used by the recipients in the purchase of text books.

The Association also provides $250 scholarships which are awarded annually in the first three years at the University of Toronto and Queen's. Each award is made to the student who, taking honours in engineering, obtains the highest standing in his work in the academic year.

OBITUARIES

John Hammersley-Heenan, M.E.I.C., a life member of the Institute, died at North Hollywood, California on January 17, 1960. He was 80.

Born in New London, South Africa and graduated from Central Technical College in London, England, Mr. Hammersley-Heenan became assistant engineer to the admiralty in charge of construction of Admiralty Harbour, Dover, in 1900.

In 1902 Mr. Hammersley-Heenan was made engineer in charge of design and construction at the Port of Durban, Natal, South Africa. He visited Canada in 1910 and established what is now known as the Dominion Engineering and Inspection Company. He practiced as a consulting engineer in Montreal until the outbreak of World War I at which time he took over the supervision of supplies and inspection of materials purchased by the Union of South Africa in Canada and the U.S.

After the war Mr. Hammersley-Heenan settled in the U.S. and worked as an engineer with the Pan Pacific Piling and Construction Company in Wilmington, California. During World War II he did construction work in that city for the Navy. From the end of the war to the time of his retirement, Mr. Hammersley-Heenan did survey and subdivisioning work in and around Los Angeles and San Diego.

Word has been received of the recent passing of **Norman T. Smith** in Phoenix, Arizona. General manager of Nova Scotia Light and Power from 1949 through 1957, Mr. Smith had lived in Arizona since his retirement.

Francis Darrell Gifford, M.E.I.C., died in Colborne, Que. on January 8, 1960. Earlier this month he had been granted a life membership in the Institute.

Mr. Gifford was for many years resident engineer for the Huntsville division of the Department of Highways, Ontario. In 1950 he was appointed inspecting engineer of the Department of Resources and Development, Special Projects Branch, Trans-Canada Highways Division.

A Major in the Royal Canadian Army in World War II, Mr. Gifford was awarded the Military Cross.

J. W. H. Ford, M.E.I.C., a life member of the Institute and an authority on hydraulic development, died at Preville, Que. on January 24, 1960. He was 70.

A graduate of the University of Toronto in 1915, Mr. Ford went to work with the W. I. Bishop Company on construction of paper mills at Ste. Anne de Beaupre, Que. and Grand Falls, Nfld. He later was employed as superintendent for Shawinigan Engineering at LaTuque and Rapide Blanc power developments. For a time he was on loan to the Aluminum Company of Canada as superintendent of the Shipshaw power development.

Upon retirement in 1956 Mr. Ford joined the St. Lawrence Seaway Authority as assistant to the chief engineer of construction.

William Albert Bickell, M.E.I.C., of Vancouver, B.C. died on August 30, 1959. A member of the Institute since 1944, Mr. Bickell worked at the Directorate of Works and Construction in Ottawa until his retirement in 1946.

From Ottawa Mr. Bickell went to Vancouver and was engaged in the contracting business.

Charles John Chaplin, M.E.I.C., a member of the Institute since 1904, died in August, 1959. For more than twenty years Mr. Chaplin was timber mechanics officer in Forest Products Research (Department of Scientific and Industrial Research), England.

In 1945 Mr. Chaplin left his post and returned to Canada. He was living in Almonte, Ontario at the time of his death. Mr. Chaplin was given life membership in the Institute in 1947.

Bary James Ferries, JR.E.I.C., was the victim of a recent boiler explosion at the Portage La Prairie, Manitoba works of the Inter City Gas Company. He had been chief engineer there for three years.

Mr. Ferries graduated from the University of Manitoba in 1955 with a degree in mechanical engineering. He was a member of the Association of Professional Engineers of the Province of Manitoba and a past chief engineer of the Winnipeg Chapter of the Sigma Phi Delta fraternity.

Victor Anthony Harvey, JR.E.I.C., died as the result of an automobile accident on April 10, 1959.

A graduate of the University of Toronto in civil engineering, 1953, Mr. Harvey was employed in the design department of the Ontario Hydro-Electric Power Commission, Toronto.

Gerhard Herrman Heyn, M.E.I.C. died on August 29, 1959. Mr. Heyn established a private practice as a consulting engineer in 1951 in Toronto.

In 1952, in a private capacity as project engineer representing E. & B. Cowan, Consulting Engineers, Montreal, he worked on the St. Lawrence Corporation's expansion program at Red Rock, Ontario.

Thomas Lees, M.E.I.C. died on August 24, 1959, after a long and interesting career with the Canadian Pacific Railway Company.

Mr. Lees went to work with the company in 1905 and in 1923 was made district engineer at Calgary. In 1941 Mr. Lees was transferred to Vancouver to assume the duties of district engineer there.

Upon retirement Mr. Lees came East. He resided in Saint John's, Newfoundland until his death.

Norman Wagner, M.E.I.C., died on November 25, 1959. He had been a consulting structural engineer in Hamilton, Ontario for many years.

A graduate in civil engineering from the University of Toronto in 1910, Mr. Wagner was a partner of Wagner and Oliver in Hamilton before going into private practice.

LIBRARY NOTES

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

***CYROGENIC ENGINEERING**

Although the practical aspects of cyrogenic processes and equipment are emphasized, an effort is made to include the theoretical fundamentals required for understanding the subject. The major problems encountered in the development and application of low temperature techniques are described, including the liquefaction and separation of gases, cooling by adiabatic demagnetization, measuring low temperatures, low temperature insulation, and the storage and transfer of liquified gases. Two concluding chapters provide handbook type information on the properties of very cold fluids and solids. The material given treats of the most recent developments and is organized with a view to indicating the feasibility of any new project, as well as the difficulties which may be encountered. (R. B. Scott. Toronto, Van Nostrand, 1959. 368p., $6.00.)

***INTRODUCTION TO THE THEORY OF COMPRESSIBLE FLOW**

The fundamentals of compressible flow are described, ranging from basic assumptions and formulation of theory to various methods of solving the problems involved. The physical properties of gases are reviewed and followed by a detailed discussion of the theory of compressible flow of inviscid fluids in relation to both steady and non-steady flow. In addition such advanced topics as transonic flow, hypersonic flow and rotational flow are thoroughly examined. In the last three chapters the author provides a detailed analysis of a viscous compressible fluid including the effect of chemical reaction and electromagnetic forces. (Shih-I Pai. Toronto, Van Nostrand, 1959. 385 p., $10.50.)

***THE SCIENTIFIC REVOLUTION**

A long term assessment of the challenge created by the scientific revolution which the satellite launchings symbolized. The authors open with a discussion of this scientific revolution and its implications for the United States, move on to an appraisal of the problems faced in developing a science program adequate to the nation's needs, and then evaluate the role of science in society and the effect of a lack of public understanding upon science and the scientist. The concluding sections examine the adequacy of the educational system in providing the human resources needed. (Ed. by G. W. Elbers and Paul Duncan. Washington, Public Affairs Press, 1959. 280p., $6.00.)

LUBRICATION SCIENCE AND TECHNOLOGY

Papers on the theoretical and practical aspects of lubrication. Among the topics considered are the lubrication of bearings, the lubrication of slider blocks, fretting of hardened steel in oil, wear and frictional characteristics of some nickel base alloys, studies of wear in relation to lubrication problems, ceramic cutting tools, synthetic sapphire as a bearing material, etc. These papers form volume 1 number 2 of the Transactions of the American Society of Lubrication Engineers, and are a complement to their periodical Lubrication Engineering. (Ed. by John Boyd. New York, Permagon, 1958. 114 p., $10.00.)

WORK MEASUREMENT IN THE OFFICE

It has been estimated that the productivity of the average office worker could be increased by 20 to 60 percent. This volume is a guide to the use of work measurement to increase production.

The authors explain how to organize a work measurement programme, and make a pilot study. The various techniques used for gathering information are described, compared and evaluated. Finally the authors discuss ways of adjusting work standards, of their use in measuring performance, and in office incentive plans.

All those interested in increased office efficiency will find many useful ideas in this book. (E. V. Grillo and C. J. Berg, Jr. Toronto, McGraw-Hill, 1959. 186 p., $6.65.)

WAGE ADMINISTRATION

Intended primarily to give the reader the basic information needed for successful wage administration, this volume analyzes the tools used, and shows how others have applied them to the problem.

After an introductory section, the author discusses the determination of the relative worth of jobs, by the use of job evaluation and analysis, job ranking and classification, etc. The next sections are concerned with the determination of the going wage, wage surveys, payment plans, incentives, etc. Two chapters deal with personnel rating, and the control of the wage administration programme. A final chapter contains problems. (C. W. Brennan. Homewood, Ill., Irwin, 1959. 439 p., $8.10.)

PRACTICAL DREDGING

The author has had much practical experience of dredging in both South Africa and the United Kingdom, and has written this book for those actually engaged in dredging operations. He discuses the various types of dredger now available, their functions, and their management and operation. Also covered are preliminary surveys, borings, currents, dredging gear, buckets, moorings, reclamation work, overhauling gear, etc. There are many illustrations of the different types of dredgers and gear, adding to the value of this useful practical text. (H. R. Cooper. Glasgow, Brown, Son and Ferguson, 1958. 270 p., 65/-.)

PRINCIPLES AND PRACTICE OF FLOW METER ENGINEERING, 8TH. ED.

This eighth edition has been enlarged, and includes new primary devices, different tap locations, and the use of electronic computers.

All aspects of flow measurement and metering are covered, including an introductory section on general flow measurement and meters, and liquid, steam and gas flow measurement. Much of the information is presented in graphs and tables, and there is a useful bibliography. (L. K. Spink. Montreal, Foxboro, 1958. 549 p., $15.00.)

SCIENTIFIC RUSSIAN

Already known for his guides to scientific French and German, the author has now written a text for those wishing to read scientific Russian. All the major grammatical constructions are covered, and the emphasis throughout is on reading passages taken from Russian texts. The explanations given are clear, and this will be a useful manual either for beginners or for those wishing to refresh their memory on some point. (G. E. Condoyannis. New York, Wiley, 1959. 225 p., $3.50.)

ELEMENTS OF SOLID STATE THEORY

Intended for graduate and other advanced students, this volume presents a brief outline of the theory of solid state physics. The subjects covered are: geometry of the crystalline state; diffraction of radiation by crystals; dynamics of lattice vibrations; co-operative phenomena in solids; one-electron theory of solids, metals; semi-conductors; friction in electron dynamics; Ohm's law; solid cohesion and chemical bonding. Problems and an extensive bibliography are included in each chapter. (G. H. Wannier. Toronto, Macmillan, 1959. 270 p., $6.00.)

JIGS, TOOLS AND FIXTURES, 5TH. ED.

In this fifth edition, a new chapter has been added on indexing mechanisms, the chapter on press tools has been enlarged to include information on die construction, crop feeding and die layout for delicate pressings.

The author describes the drawing and design of all types of equipment used with machine tools: jigs, chucks, cutters, gauges, cans, jig bushes, materials. A useful practical book. (Philip Gates. Toronto, General Publishing, 1959. 215 p., $6.00.)

SIXTH REPORT OF THE CORROSION COMMITTEE

The fifth report of this Committee of the Iron and Steel Institute was presented in 1938. This report includes a review of progress in the last twenty years, and of the work of the Committee in the fields of atmospheric, marine and soil corrosion, corrosion by industrial waters, protective coatings, corrosion test procedures, and research. More detailed information is given on tests conducted on the atmospheric corrosion of iron and steel, corrosion and protection up to 300°C and marine corrosion. (J. C. Hudson, comp. London, Iron and Steel Institute, 1959. 217 p., £3.3.0.)

THE UNCOMMON MAN

Du Pont's tenth president presents his philosophy of business management in this volume, which is based on a series of lectures given at the Graduate School of Business Administration at Columbia University. His thesis is that organizations, nations, societies and civilizations will prosper only to the extent that they can encourage common men to perform uncommon deeds. In this way emerges the Uncommon Man.

Mr. Greenwalt gives his ideas on executive training and evaluation; political science; social organization; taxation. His thoughts will be intensely interesting to all those interested in modern society. (C. H. Greenwalt. Toronto, McGraw-Hill, 1959. 142 p., $4.60.)

L'INDUSTRIE ATOMIQUE EN FRANCE ET DANS LE MONDE

The book is divided into three parts—technical data, economic factors and programs of nuclear development in the U.S.S.R., the U.S.A., Great Britain, and France. Within these subdivisions, the author discusses nuclear fission, use of radioactivity, raw materials, national nuclear programs and the international work being done in this field. The history of energy, its potentials and uses are considered in detail. (C. Benoit. Paris, Dunod, 1959. 159 p.)

BASICS OF MISSILE GUIDANCE AND SPACE TECHNIQUES, VOLS. 1 & 2

This two volume "picture book" explains in elementary terms the fundamentals of the important areas of electronics that will contribute to the conquest of space. The books are divided into two broad parts. Volume 1 covers the principles of control and guidance and gives extensive coverage to such topics as radio and radar command links, computer applications and celestial navigation. Volume 2 emphasizes telemetering, space exploration by optics and electronics, satellite theory and practice, satellite monitoring and tracking as well as applications of earth satellites. Anyone with an interest in guided missiles can profit from these books (M. Hobbs. New York, Rider, 1959. 2 Vols., $3.90 each.)

TECHNIQUES OF PLANT MAINTENANCE AND ENGINEERING, 1959.

This comprehensive 10th volume in the series covers the proceedings of the conference held in January 1959. The numerous papers presented apply to all types of industries in general, whereas the round table discussions are concerned specifically with nuclear industry, abrasive products, chemical, electrical manufacturing, and metal working and metal fabricating plants as well as research and development laboratories, foundries, pulp and paper mills, and petroleum refineries. The variety of maintenance topics covered are of particular value to maintenance engineers in small and large plants. (New York, Clapp & Poliak, 1959. 266 p., $10.00.)

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● LIBRARY NOTES

THE MANAGEMENT OF TIME

The author, a Montrealer, believes that the man who is always terribly busy, may be merely inefficient. He shows how time may be managed so that a man of originality, given reasonable conditions, can find time to do his work, and develop his mind also. The author also shows how management can speed up the origination of new ideas, by encouraging the "idea" man, rather than the team.

This volume should be read by all those who feel they could be getting more out of their day. (J. T. McCay. Englewood Cliffs, Prentice-Hall, 1959. 178 p., $3.50.)

NAUTILUS 90 NORTH

These three words announced the completion of the Nautilus's journey under the Arctic ice pack from Pacific to Atlantic. This account is written by her Captain. He relates all the planning which went into the successful voyage, and the previous one when the Nautilus turned back 180 miles from the Pole. He describes the secrecy in which preparations were carried out, and re-creates the atmosphere on the submarine during the historic voyage. This is a gripping story. (W. R. Anderson and C. Blair, Jr. Toronto, Nelson, Foster and Scott, 1959. 251p., $4.75.)

PHOTOGRAMMETRY

Intended primarily as a college text, this volume covers the basic principles of photogrammetry, and their application.

The greater part of the volume is devoted to aerial photography, and the topics covered include: aerial cameras; geometry of the aerial photograph; flight planning; ground control; radial-line plotting and planimetric mapping; stereoscopy and parallax; mosaics; instruments; oblique photography. The last chapter is concerned with terrestrial photogrammetry.

There are many illustrations, and long bibliographies at the end of each chapter. (F. H. Moffitt. Scranton, International Textbook, 1959. 455p., $12.00.)

HEATING AND VENTILATING, REV. ED.

The introduction to the subject, giving a broad general survey of principles and practices. The topics covered include heat losses, fuels, radiators and other heat emission appliances, boilers, heat conveyance, hot water supply, piping systems, ventilation principles and apparatus, and an example of the design of both a heating and a ventilating system. New techniques mentioned include underfloor, baseboard and radiant metal ceiling heating systems, the high pressure system of ventilation, and nuclear energy as a source of heat. This volume has been revised by L. N. Doe, a member of the original author's firm. (Oscar Faber. London, Spon, 1959. 189p., 30/-.)

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(Continued from page 134)

*THE DIESEL ENGINE

Based on the practical experience of the authors, this volume provides a survey of diesel engine operation and design. It begins with a discussion of petroleum and refining methods and of diesel fuel combustion. This is followed by the effect of the forces released by combustion on the moving parts of the engine and on the static or restraining parts of the engines. There is then a treatment of "parasitic engine parts" and a concluding section on economics, including power application. A feature of the volume is the introduction, at appropriate points, of a "basic design problem" which illustrates the theory with which it is associated. (L. V. Armstrong and J. B. Hartman. Toronto, Brett-MacMillan, 1959. 360p. $8.75.

*MATHEMATICS FOR TELECOMMUNICATION ENGINEERS

Written for the practicing engineer and the advanced student, this text covers the various phases of mathematics useful in electronics. It includes such topics as Laplace transformation and probability, complex functions, differentiation, integration, Taylor's series, and trigonometrical functions. Numerous examples help to relate the theoretical and practical aspects of the subject. (S. J. Cotton. Toronto, Ryerson, 1959. 245p. $7.50.)

*SAFETY IN PETROLEUM REFINING AND RELATED INDUSTRIES, 2ND. ED.

The five basic causes of accidents are discussed: misoperation or improper practice; equipment failure; repair of equipment while operating; lightning, windstorms, and the other effects of the elements; improper equipment and miscellaneous causes. In addition, information is given on the provision of special equipment for accident prevention and the protection of facilities, as well as special treatment of detonative combustion, control of oil spills, tank explosion and collapse, and brittle fracture and fatigue of metals. Requirements for the safest practical equipment location and spacing are indicated. (George Armistead, Jr. New York, Simmonds, 1959. 484p., $12.50.)

*ELECTRONIC FUNDAMENTALS AND APPLICATIONS, 2ND. ED.

This edition reflects the belief that the transistor and other semiconductor devices have fully proved themselves. Accordingly the fundamental phenomena underlying vacuum tubes and semiconductor devices have been consolidated into a joint treatment and points of parallelism have been emphasized. In addition the introduction of the transistor has been used as an opportunity to correlate electronics and basis network theory, and to emphasize the standard methods once an electronic circuit is reduced to a linear active circuit. Other revisions include new information on single-side-band modula-

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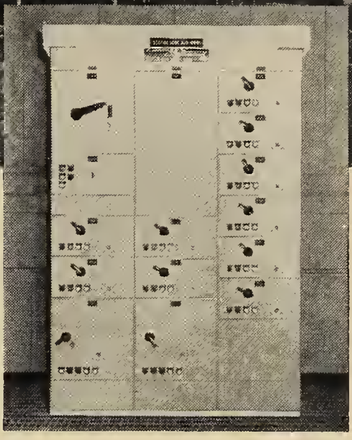

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tion, diode theory, transistor parameters and circuit analysis, direct-coupled and operational amplifiers, and voltage regulators (J. D. Ryder. New York, Prentice-Hall, 1959. 721p., $13.35.)

*INTRODUCTION TO ELECTRONIC ANALOG COMPUTERS

The basic elements of the analog and digital computer are covered with regard to differences and similarities as well as their applications. The author then reviews differential equations, classifies engineering problems, and indicates how they can be solved by electronic means. This is followed by sections on time and amplitude scaling, simulation of physical systems, problems of stability and sensitivity, generation techniques, and methods of checking analog computer results. The topological aspects of analog computers are stressed through the use of signal flow graphs. (J. N. Warfield. New York, Prentice-Hall, 1959. 175p., $6.00.)

*HOT ORGANIC COATINGS

The constitution, applications, and properties of such hot organic materials as asphalt, coal tar pitch, petroleum waxes, and cellulose derivatives are presented. Specific information on formulations of proprietary products is included. Hot melt applications without solvent such as peel coatings, protective linings, flame spraying and the fluidized bed process are then discussed, and a special chapter is devoted to hot applied coal tar pitch base coatings. Hot spray techniques and their advantages are also covered. (R. B. Seymour. New York, Reinhold, 1959. 233p., $7.50.)

*AUTOMATION AND SOCIETY

Various aspects of automation are reviewed in this collection of papers which examine the present and potential impact of automation on society. Topics presented include the evolution of automation, its application to critical industries in the American economy, the challenges of automation, and the problems it raises in the areas of education, leisure, politics, and business and public administration. The final paper by two Russian authors gives a picture of automation in the Soviet Union. A glossary of automation terms and thirty-seven short case histories are also included. (Ed. H. B. Jacobson and J. S. Roucek. New York, Philosophical, 1959. 553p., $10.00.)

*MATERIALS AND PROCESSES OF ELECTRON DEVICES

A practical manual for the physicist or engineer concerned with designing and building electron devices such as high-vacuum tubes, gas- or vapor-filled rectifiers, thyratrons, X-ray or luminescent tubes, flow or incandescent lamps, Geiger or ionization counters, vacuum photocells, photoconductive cells, diodes, and transistors. Extensive information is provided on the preparation and working of materials used in these devices; the finishing methods for vacuum tubes, particularly degassing, pumping, and getter procedures; and the production of solid state devices. A valuable feature is the approximately 2300 references given. (Max Knoll. Berlin, Springer-Verlag, 1959. 484p., 66 DM.)

*MATHEMATICAL THEORY OF COMPRESSIBLE FLUID FLOW

The book is divided into five parts: introductory materials, general theorems, one-dimensional flow, plane steady potential flow, and integration theory and shocks. The general theory of characteristics with its applications is given detailed treatment as is the theory of shocks as asymtotic phenomena. The latter theory is set within the context of rational mechanics. A thorough presentation of the hodograph method is included. This is volume 3 of Johns Hopkins Applied Physics Laboratory series "Applied Mathematics and Mechanics." (Richard von Mises. New York, Academic Press, 1958. 514p., $15.00.)

*HYPERSONIC FLOW THEORY

Concerned with the problems of determining the details of the flow field about a body placed in a high velocity gas stream. Following a general consideration of the subject, the authors continue with a discussion of the small disturbance theory, the Newtonian theory, constant-density solutions, the theory of thin shock layers, methods for solving blunt-body and locally supersonic flows, viscous flows and interactions, and free molecule and rarefied gas flows. (W. D. Hayes and R. F. Probstein. New York, Academic Press, 1959. 464p., $11.50.)

*HOCHSPANNUNGSTECHNIK

V. 1, pt. 1 Gasentladungen.
V. 1, pt. 2 Hochspannungamessungen; Hochspannungamessungens-Laboratorien.
V. 2, Isolatoren und Isolierungen.

A German translation of a comprehensive Russian work on high-voltage technology. The three books deal respectively with the following aspects:

V. 1, Part 1: Gas discharges — covering ionization phenomena, discharges in vari us electrical fields, channel discharge, duration, break-down voltage, lightning, and corona phenomena.

V. 1, Part 2: High-voltage measurements of all kinds, including surge voltages.

V. 2: Insulators and insulation for high-voltage cables, condensors, transformers, and other electrical equipment, including the pre-testing of insulation. (L. I. Sirotinski. Berlin, VEB Verlag Technik, 1955-1958. V. 1, pt. 1, 298p., 17 DM; v. 1, pt. 2, 259p., 20 DM; v. 2, 384p., 25.80 DM.)

*FLOW MEASUREMENT AND CONTROL

Emphasizes practical measurement and control of flow rather than theoretical

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concepts. Beginning with a classification of fluid meters and with tables of capacities, a discussion of differential head meters is given which includes the derivation of working formulas and explains the use of Reynolds numbers. The book then continues with primary elements for measuring differential pressures, the installation of pressure difference devices, a detailed consideration of weirs of different cross-sections and of flumes, and a survey of typical instruments used in the measurement of fluid control. It concludes with automatic control, control of continuous processes, and miscellaneous control installations. (W. F. Coxon. Galt, Brett-Macmillan, 1959. 312 p., $11.00.)

*TUNNEL ENGINEERING

A comprehensive survey of tunneling methods and recent developments that have affected tunneling practice. Following a brief history of tunneling, the book covers lining methods with practical examples, shield tunneling, and subaqueous tunneling. It continues with a chapter on rock tunneling which covers shaft sinking problems, drilling, blasting, rock falls, and shattering. Concluding sections deal with tunneling through difficult ground, and such problems associated with long tunnels as temperature control. (Rolt Hammond. Galt, Brett-Macmillan, 1959. 332p., $11.00.)

*THE THEORY OF THIN SHELLS

This translation from the Russian presents an analysis of stresses and deformation in shells, treated as a linear problem with displacements assumed to be small in comparison with the thickness of the shell and strains not to exceed the limit of proportionality. The four chapters treat the general theory of thin shells, the membrane theory, analysis of cylindrical shells, and shells of revolution, giving a unified point of view based on a wide utilization of complex transformations. (V. V. Novoshilov. Groningen, The Netherlands, P. Noordhoff, 1959. 376p., $9.50.)

*THE TECHNOLOGY OF PRINTED CIRCUITS

Beginning with an account of the invention and development of printed circuits techniques, the author provides a detailed explanation of printed circuit production which includes such aspects as a typical production line, suitable printing methods, plating and foil techniques, protective coatings, flow and dip soldering, and potting. In addition details are provided for the design of printed circuits, the insertion of conventional components into the printed circuit, and the detection and tracing of faults. Recent developments examined encompass automatic assembly, miniaturization, printed components, and microwave printed circuits. (Paul Ersler. New York, Academic, 1959. 405p., $12.00.)

*HYDRAULISCHE PRESSEN, VOLUME III

This third volume of a German treatise on hydraulic presses and installations deals with extrusion presses for the manufacture of metal tubes and cables. It reviews the design, working elements, and operation of such presses, as well as the recent processes based on modern practice. There are special chapters on presses for the production of lead tubes and cables, presses for the production of lead and aluminum cable sheath, and on practical construction details. (Ernst Muller. Berlin, Springer-Verlag, 1959. 265p., 43.50 DM.)

*HYDROLOGY, 2ND. ED.

This volume covers stream flow, its fluctuations and their causes, and includes the presentation of a method using the unit hydrograph principle for determing the magnitude of floods that may be expected to occur with specified rare frequencies on any given stream. In this second edition two new chapters on the hydrology of semi-arid basins and the effect of snow on the hydrology of an area have been added. Runoff, precipitation, soil moisture, water losses, ground water, floods, and stream flow records are dealt with; and field problems concerning methods of flood reduction, the evaluation of potential water power on a river, water conservation practice and determination of spillway and bridge discharge capacities are also presented. (C. O. Wisler and E. F. Brator. New York, Wiley, 1959. 408p., $9.25.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aeronautical engineering

Approximate method for determining the potential flow about an arbitrary aerofoil section in a two-dimensional finite stream with particular reference to large stream deflections, by D. G. Gould. Ottawa, National Aeronautical Establishment, 1959. (Laboratory Report 260).

An experimental study of rotating stall in a two-stage axial compressor, by R. F. Meyer. Ottawa, National Aeronautical Establishment, 1959. (Laboratory Report 259.)

Bridges. Design

Design of highway bridges in prestressed concrete. Chicago, Portland Cement Association, 1959.

A record of history and evolution of early American bridges, by L. N. Edwards. Orono, Maine, University Press, 1959. $5.00.

Canada

Ceramic plants in Canada. Ottawa, Dept. of Mines and Technical Surveys, Mineral Resources Division, 1959. 25c.

Selected bibliography of Canadian geography with imprint 1957. Ottawa, Dept. of Mines and Technical Surveys, Geographical Branch, 1959. (Bibliographical series no. 23). 50c.

Staffing the universities and colleges of Canada; a study by the Research and Information Service of the Canadian Universities Foundation, dir. by E. F. Sheffield. Ottawa, Canadian Universities Foundation, 1959.

Working and living conditions in Canada. 8th ed. Ottawa, Dept. of Labour, 1959. 25c.

Coal. Combustion

Combustion of eastern Canadian coal in thin fires on a spreader-fired air-cooled oscillating grate, by E. R. Mitchell and others. Ottawa, Dept. of Mines and Technical Surveys, Mines Branch, 1959. (Technical bulletin 1.) 25c.

Computers

The solution of an eigenvalue problem (rate of evaporation and decomposition of a droplet of an ozone-oxygen mixture) by means of analogue and digital computers, by R. Sandri. Ottawa, N.R.C., 1959. (Mechanical engineering report 15.)

Concrete construction. Prestressing

Ultimate flexural strength of bonded prestressed concrete. Chicago, Portland Cement Association, 1959.

Electrical engineering

Electrical Research Association reports:— CL/T1: Summary of proceedings at international symposium on electricity in the tropics: 1. Climatic conditions and equipment, by M. E. Thompson. 30s.0d. F/T 194: Heating of cables: transient temperature rise due to a line source in a semi-infinite medium with a radiation boundary condition, by H. Goldenberg. 7s.6d. G/XT 161: Circuit interruption in vacuum, by M. P. Reece. 7s.6d. L/T 388: The I.E.C. tracking test; design of an automatic tracking comparator, by N. Parkman. 7s.6d. L/T 357: The impulse breakdown of uniform-field gaps in air; interim report, by R. Galloway. 12s.6d. O/T 17A: The prevention of internal decay in creosoted Baltic redwood poles. 6s.0d.

O/T 20: The protection of 11 kV and 33 kV bushings from damage by arcs in still air and in a wind, by A. E. Guile and S. F. Mehta. 12s.0d.

age 25/30 having a minimum of three years industrial experience in work measurement and related areas of industrial engineering. Attractive compensation range. Applications should provide full particulars and will be held in strict confidence. File No. 6915-V.

SALES ENGINEER — Excellent opportunity for aggressive graduate Mechanical or Chemical engineer, 25-35 years of age who is interested in selling engineered equipment to Pulp & Paper Industry. Some experience in Pulp & Paper Industry desirable. Reply in confidence to File No. 6921-V.

SALES ENGINEERS, two recent graduates, Mechanical or Electrical required by progressive manufacturer of ventilating, air conditioning and related engineered products. Some experience preferred, but not essential. Following completion of company training course successful candidates will be assigned to Hamilton and Montreal Branch Sales Offices. Wide range of employee benefits and attractive starting salary. Send complete resume and salary requirements. File No. 6923-V.

PUBLIC HEALTH ENGINEER for administrative work in engineering problems associated with non-municipal water supplies and sewage disposal, mild and other food processing plants, swimming pools, new subdivision proposals and general sanitation. Liaison with local health agencies and municipalities with some travelling involved. Engineering graduate with not less than 3 years post-graduate experience in municipal or related public health work. Send summary of education, qualifications and experience to Director, Environmental Sanitation Division, Ontario Department of Health, Room 519, Annex, 67 College Street, Toronto 2, Ontario. File No. 6927-V.

MECHANICAL OR AERONAUTICAL ENGINEERS are required for employment with major airline at Winnipeg. Must be graduates with extensive experience in aircraft structures and power-plant engineering. Full complement of employee benefits and opportunity for advancement. Replies must include details of personal history, professional training and experience. File No. 6933-V.

Business and Industrial Briefs

Year-Round Service as a supply, buoy, search and rescue vessel is ahead of the C.G.S. "Tupper", recently launched at Marine Industries Limited, Sorel, P.Q. Fairbanks-Morse and Canadian Westinghouse supplied propulsion machinery for the ship, commissioned by the Department of Transport for duties in Maritime and Gulf of St. Lawrence waters.

Wrinkling, Shrinkage and moisture transmission are resisted by KST "Cellophane" cellulose film, which Du Pont of Canada produces at its Shawinigan plant. Originally developed as a direct-wrap material, KST has now come through tests that prove it equally useful in the carton overwrap field.

Walworth Industrial Valves will be manufactured and sold in Canada by Canada Iron Foundries Limited, Montreal, under an exclusive licensing arrangement with The Walworth Company, New York. Bronze, iron, steel, plastic and lubricated plug valves are included in the Walworth line.

More Power For Less Air, through a patented valve system — an attractive feature of Atlas Copco's E 20 paving breaker — is true also of the E 40, a new heavy-duty breaker which the company says has a higher output than any other of its size on the market. The new model also offers the advantages of low recoil, simpler lubrication and easier dismantling.

Insulating Group Piping and straight runs of large pipes from 0°F. to 1200°F. is a job for which Spunrock pipe insulation is especially suited. Spun Rock Wools Limited of Thorold, Ont. produce this material, which is recommended for stainless steel piping as it is chemically inert. Spunrock has an extremely low heat transfer coefficient, is resilient, and does not crumble or dissolve in water. It can be shipped flat, saving space in warehouse and truck.

Stiff Competition from the U.S.A., Germany and Japan was overcome by L'Air Liquide, manufacturing affiliate of Canadian Liquid Air Company, Montreal, to secure a $1,600,000 contract from the Yugoslav Government for a low temperature gas separation plant. The Development Loan Fund in Washington is financing the project, and the plant will be shipped sometime this year. It will produce in twelve months 100,000 tons of oxygen and 120,000 tons of ammonia synthesis gas, with a quantity of the rare gas argon as a by-product.

Brighter and More Uniform illumination is given to any plastic facing or cap colour used in front of a neon glow lamp with a round end produced by Canadian General Electric's Lamp Department. The radically different design allows placing of the electrodes closer to the end of the lamp, which helps also when wide-angle viewing of the bare lamp, indicator unit, or panel is necessary.

Only Three Sizes of rotating parts are required for the complete new line of "Canadian Buffalo" Paper Stock Pumps announced by Canada Pumps Ltd. of Kitchener. The new line offers considerable savings in maintenance time, spare parts inventory, and replacement costs.

The Biggest Blast ever fired in Venezuela detonated 88 tons of CIL "Nitrone" at the Caroni River Hydro-Electric Project recently.

Air Conditioning Boomed last year, and despite record shipments every month since June, the Trane Company of Canada still has the largest backlog of orders in its 35-year history. A plant extension will add 55,900 square feet to factory and office space by May.

Picket-Size Hook-On volt ammeters for testing a-c voltages have been introduced by General Electric.

Error Correction For Radio Teletype communications has been explained to Department of Transport personnel in the first formal course conducted by Siemens and Halske, manufacturers of equipment which recognizes errors as they occur and refuse to print them.

Dofasco's Pig Iron Capacity will increase approximately 50% with the opening of a new blast furnace expected late this year. The company will also extend bay front facilities at its Hamilton headquarters, and plans to spend some $20 million on improvements in 1960.

Unnecessary Steps and lost time prompted Canadian Westinghouse to introduce a continuous chain dragline system which travels throughout the warehouse at York Mills, the company's Ontario distribution centre. Moving under the floor, the system pulls four-wheel carts which can be unhooked from the dragline and moved into the stock areas for loading or unloading. A warehouseman, who under most systems must make at least some regular journeys without a load, will work strictly in his assigned area. Each of several such areas is serviced with stock and orders by the underfloor conveyor system.

India's Steel Output is being increased from 1.3 million tons in 1955-56 to six million tons in 1960-61. On December 29 last the new steelworks at Durgapur was opened. This plant is an undertaking of 13 United Kingdom firms, a consortium formed especially for this project and called the Indian Steelworks Construction Company Ltd. (ISCON). Completion is expected by August, 1961, and initial annual output will be based on the production of one million tons of ingots.

Hearing Loss is measured by the M-S-A Noise Integrator, recently introduced by Mine Safety Appliances Company of Canada Limited. By integrating signals collected during five-second cycles, the instrument provides data from which it is possible to predict the degree of hearing loss that would normally result from a five-year exposure to a particular noise level.

Canadian Manufacture of Ellicott dredges and dredging machinery is the object of an association between Timberland Machines Limited, of Woodstock, Ont. and the Ellicott Machine Corporation of Baltimore. A new company, known as Timberland-Ellicott Limited, will manufacture not only for the Canadian market but for the sterling area and other established overseas markets for Canadian products.

(Continued on page 152)

• BRIEFS

(Continued from page 150)

Film For Fighting forest fires is a new technique permitted by the development of a durable polyethylene film in the laboratories of Union Carbide Canada Limited. Small artificial ponds are provided in forested areas through the use of 8 mil. black polyethylene liners fabricated by Northwest Polyrama Limited of Edmonton. The film eliminates loss of water that would normally seep through the soil.

Takeover by Orenda Industrial Limited of the Canadian sales and servicing of Standard-Triumph products is announced in a joint statement. Orenda Industrial will market, service and provide engineering support for the complete range of Standard-Triumph's diesel, gasoline and natural gas engines covering the agricultural, marine and general industrial fields.

No Moving Parts and no radio tubes are to be found in power controllers of a new type offered by Polytronics Company, 582 Bathurst St., Toronto. The power controllers can be used for such purposes as dimming lights, controlling temperature, and various chemical processes, and are manufactured in Canada.

Canadian Curtiss-Wright Limited has developed a new electric furnace for homes. Operating directly from standard wiring for 100-ampere service, the Thermapac Series B furnace is attached to ceiling joists and forms part of the heating ductwork in a hot-air heated home.

B. F. Goodrich have compiled a hose chart to assist users of rubber hose in a wide variety of specialized fields. This guide describes hundreds of uses for precision engineered industrial hoses.

Premium Iron Ores Limited intends to build a steel plant in the Fort William-Port Arthur area, at a cost of $10,000,000. It will use the HyL process engineered by Canadian Kellogg Company.

Canadian General Electric Company Limited have available an illustrated eight-page bulletin entitled "G-E Silicone Antifoams". Write to Chemical Materials Section, Canadian General Electric Company Limited, 940 Lansdowne Avenue, Toronto 4 for Bulletin CDS-204.

Canadian Kodak Company Limited provides a new set of high-speed autopositive papers to meet the printing industry's need for a quick, easy way to obtain proofs of paste-ups.

Furlong Plastics Company's Toronto plant is turning out in quantity such parts as swivel corners for tilting storm windows, window latches, rubbing blocks for windows, and wheel-and-frame assemblies for patio-type sliding doors. Small runs of nylon parts are produced economically using "Zytel" nylon resin manufactured by Du Pont of Canada at Kingston, Ont.

Canadian Westinghouse Company Limited are doing research in their new nuclear-metallurgical laboratory that could reduce the capital cost of nuclear power reactors. Investigations into the properties of beryllium under stress at high temperatures have been undertaken for Atomic Energy of Canada Ltd.

The McBee Company Limited has released a six-page brochure describing a new complete highway design program now available for the McBee LGP-30 electronic computer. Copies may be obtained by writing for S-519 to The McBee Company Limited, 179 Bartley Drive, Toronto 16.

B. F. Goodrich, chemical Division has developed a unique polyurethane material with resistance to abrasion wear. The product 'Estane' will have tremendous market potential in the automotive, electrical, footwear, textile and other industries, it is claimed.

(Continued on page 154)

• BRIEFS

(Continued from page 152)

Goodyear Tire and Rubber Company of Canada Limited have a Belt Splice and Repair Manual available. In addition to this authorative guide to belt maintenance the Company offers to train men and to rent vulcanizers.

American Air Filter of Canada Limited, 400 Stinson Blvd., Montreal, have available upon request a 28-page manual of Exhaust Hood Designs for the Foundry Industry.

Canadian SKF Company Limited sent its vice-president, Engineering, to attend as Canadian delegate, the International Organization for Standardization in Berlin recently.

Dresser Manufacturing Division are shipping what they claim are the largest solid ring pipe couplings ever built — 16 feet in diameter — by a devious route to avoid tunnels, low overpasses and bridges on special flat cars. Each of is designed for operating pressures exceeding 288 psi.

Time Sharing is the secret of the Orion data-processing system announced in Britain by Ferranti (Ferranti Packard Electric Ltd., Industry St., Mt. Dennis, Toronto 15). The keyboards can be operated continuously, even though the computer itself is doing other data-processing work.

Preparing Purchase Orders by copying the original requisition directly onto Verifax Copy Paper preprinted with the purchase order heading is one of the procedures described in a four page leaflet on the versatile Canadian Kodak Verifax system.

The World's Largest blender has been introduced by The Patterson-Kelley Co., Inc., using its patented Twin Shell design. Two cylinders cut at right angles and joined to form a V-shaped design can uniformly blend at one time enough plastic powder to fill two railroad hopper cars.

When Hulls Were Deformed but not ruptured by nearby explosions of mines and torpedoes, and tough alloys were sometimes found shaped around softer metals, U.S. naval scientists thought the information well worth publishing. Commercial application of this phenomenon is the objective of experimental studies at the new CIL explosives research laboratory, McMasterville, Que. Although some metal forming is accomplished in a gaseous medium, the bulk of the work is done with the dies, blank and explosive charge submerged in water, which transmits the shock pressure more effectively. The versatile new technique for metal working employs two methods. In free forming, the parts are formed with open-ended dies. Closed die forming requires a machined die sealed off from the water and evacuated. Explosives have already been employed in the manufacture of fuel tanks, booster cases for rockets and sound suppressor tubes for jet engines.

THE THOMPSON MINE of International Nickel, which starts operations this year and will come into full scale production in 1961, will be the largest nickel producing operation in the world next to Sudbury. The Manitoba project is being financed entirely from Company funds, and INCO's capital investment will approximate $115,000,000.

SUPER SEAL MOTORS are particularly emphasized in the appointment of Canmark Services Limited as national distributor of electric motors and control for Canadian Allis-Chalmers. Formed last year by twelve companies as associate members, Canmark provides nationwide engineering sales and services, warehousing, installation and service, and now consists of an affiliation of more than twenty separate distributing companies.

NARROW AISLE HANDLING is facilitated by use of the Raymond Corporation's new heavy duty electric truck. Development of a single wheel drive with offset caster enables the Company to sell the new model at a lower price while retaining most of the features of the original dual drive unit.

GROUT FAILURE is chiefly caused by shrinkage. The Master Builders Company, Ltd., Toronto 15, has produced a 16 page booklet which explains how to avoid this shrinkage with Embeco non-shrink grout and illustrates varied applications of cold and hot weather grouting.

THE WIRE TIRE, commercially available since 1957, was one of many developments surveyed in a paper presented to the American Society of Mechanical Engineers by Leora E. Straka, research librarian for Goodyear. The new tire contains no rubber and no fabric, and needs no inflation. In addition to its advantages for directional and braking control, it can withstand temperatures from 1000°F. to 2000°F. that might be encountered by a space craft re-entering the earth's atmosphere.

MECHANICAL PROPERTIES OF SILICONE FLUIDS are of interest to engineers designing equipment for use in high temperatures and other extreme conditions. Bakelite Company, division of Union Carbide Canada Limited, 40 St. Clair Avenue East, Toronto 7, has assembled a handy design file with charts, that can be obtained by design engineers and others. Some of the graphs are on 17" by 11" sheets, so that the designer can work right on them.

THE SPRING DESIGN permits the small envelope and light weight of a high pressure reducer for air or nitrogen which weighs only 8 ounces. Gas at 3,000 psi can be reduced to 300 psi, or to any pressure between 300 and 1800 psi by selecting the proper spring for the assembly. Excellent control of the downstream pressure is assured by the balanced design of this reducer, manufactured by Walter Kidde & Company, Inc., Aviation Division, Belleville 9, N.J.

SINGLE-LEVER REMOTE CONTROL for outboard motor boats has been made possible through the use of moulded nylon parts. The unit, known as the "Whitney Automatic" outboard control, is intended to replace customary two-lever controls, and its inventor C. W. Buddo, president of Lake Controls Limited, Toronto, has also adapted it to a steering wheel control for outboards. The nylon moulding operation is done by Midland Plastics, Midland, Ont.

EVERY FOUR YEARS the Machine Tool Trades Association of the United Kingdom organizes in London's Olympia exhibition halls the International Machine Tool Exhibition. At Olympia from 25th June to 8th July 1960 it will be possible to see under a single roof, machine tools from practically every country in the world.

EASY DISPERSION and a smoother texture with no loss of brightness are characteristics imparted to aluminum paints by an unusually versatile new leafing pigment designated as Alpaste 101. Samples of the new pigment can be obtained from the Chemicals Division, Aluminum Company of Canada, Ltd., 1700 Sun Life Building, Montreal.

ELECTRO-PRECIPITATION both for preventing atmosphere pollution and for recovering valuable materials is one of the many activities of Simon-Carves, the British engineering group which had its beginnings some eighty years ago and has opened offices in Toronto. Simon-Carves also have over fifty years' experience in mine engineering, covering the design, supply and construction of large installations from reception of mined material at pit bottom to despatch of cleaned products from rail sidings.

AN ALKALI-CHLORINE plant that will cost $2,600,000 is being built by Cominco at Trail, B.C. This venture in heavy chemical manufacture stems from a sales agreement with Celgar, Limited. Cominco will supply the liquid chlorine and caustic soda required for Celgar's $50,000,000 kraft pulp mill, and will also produce potassium hydroxide for its own processes at Trail.

A GAS TURBINE is now at work in the Canadian petrochemical industry. Ruston and Hornsby supplied the turbine which has recently been installed at the Edmonton polythene plant of Canadian Industries Ltd. It is coupled to a package Carrier freon unit as part of a low temperature ethane recovery plant.

• DISCUSSION

(Continued from page 79)

stance, has experienced bitter industrial warfare as long as its management (mostly engineers) has not understood the fundamental difference there is between a punch press and the operator behind it.

Engineers of the present generation know better. Those especially who have shouldered administrative responsibilities know that non-technical knowledge integrated with technological know-how is as important as technical knowledge itself.

The important thing is the integration of the two. I contend that no other institution in our society is better qualified than engineering schools for the *simultaneous process* of transmitting non-technical information and integrating it with the body of traditional engineering education.

Imparting knowledge is an important aspect of professional education, but it is not the only one.

b) Intellectual powers. Engineering curricula are designed to develop to a high degree analytical abilities and, to a lesser extent, to improve synthetical and creative powers.

These abilities are the lifeblood of engineering practice; they are also most valuable in management. Yet, the engineer must be conscious that the mode of application of analysis, synthesis, creation, is radically different whether he deals with things or with men or with both.

c) Attitudes. They are called self-confidence, openness to experience, willingness to take risk, desire to understand the other fellow's point of view, etc., etc., etc.

The development of attitudes has long been an "unconscious" objective of higher education. However, as of this day, attitudes have not yet been clearly defined nor identified. This reflects the lag of the science of man behind technology.

But what about their importance? Educators generally agree that proper attitudes are as important as knowledge for an effective personal life and professional career. Our colleges of applied science have been successful in helping their students develop some of the right attitudes for engineering practice. This is good, but not enough. Under the present circumstances, engineering schools have the further responsibility of creating for their people opportunities to develop the attitudes expected in high-grade private and public administrators.

Responsibility to engineering as a profession

Ministry to the people: this, I believe, is the idea of a profession. Historically, engineers have done a grand job in harnessing the forces of nature in the service of mankind. The prestige of the profession has grown accordingly.

Today, engineers continue to serve their fellow men in this way, but one half of the profession is called on to give society what it is badly in want of — leadership.

Engineering schools have always aimed to supply the profession with men of the right ability, character and motives. In the second half of the twentieth century, the engineering profession is expected to deliver both: outstanding technical performance and leadership of the highest possible order. The profession, I believe, really has nowhere else to go but to its professional schools for help in these most demanding tasks.

Our institutes of technology have made clear they will do all they can to enable their people to cope with higher and higher standards of technical performance. On the other hand, I am at a loss to understand why educators of the standing of Prof. Carpendale and of Prof. Hughes are hostile to the idea of leadership studies within engineering school, which after all, are as important to the profession as technological instruction. Here is a responsibility to the engineering profession our colleges of technology can hardly evade — nor can they "pass the buck" to anybody else.

Responsibility to society as a whole

By giving young men the right education and training for a fuller personal and more effective professional life, by supplying the profession with people who spend their career in the service of their fellow men, engineering schools perform a most valuable function in society.

The other major social responsibility of professional schools is to broaden and deepen knowledge. Over the years ahead the pursuit of knowledge in technical fields will grow in importance. More important still will be the adaptation of technology to what Carrel called "la nature profonde de l'homme". This blending of the science of things with the science of man will require hard thinking, and hard thinking is the purpose of graduate and post-graduate studies.

As I wrote earlier, the demand on the engineer today is for *applied technical science — engineering — and for applied human science — administration —*. How well will the engineer measure up to this challenge? The reply, for a large part, lies in what engineering schools will do (or not do) in the next few years.

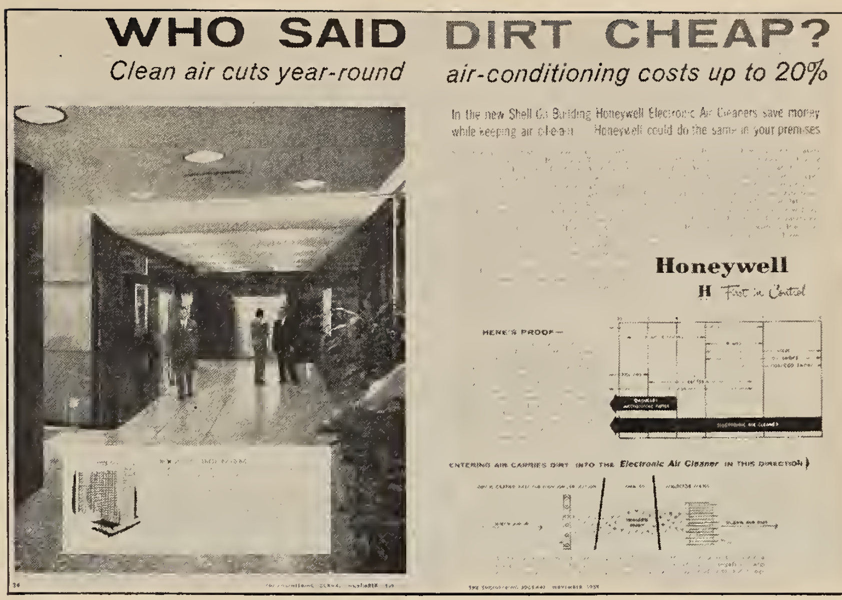
By creating opportunities for engineers to graduate and post-graduate studies in administration, our institutes of technology would serve the engineer, the profession and society. They would do a much-needed task, a task nobody else could perform effectively.

Honeywell Controls Limited are the winners of the E.I.C. Certificate of Advertising Merit for the "best" advertisement in the November 1959 issue.

This is the second time in 12 months that this organization has won a certificate. The advertisement which is headed: "WHO SAID DIRT CHEAP?" appears on pages 14 and 15 of the issue. It explains how Honeywell Electronic Air Cleaners save money, while keeping the air clean, in the new Shell Building in Toronto, Ontario.

The left hand page of the advertisement consists of a large illustration and inset is a brief description of the building and the air-conditioning equipment and gives further details on the new $6,000,000 Shell Building. The copy on the right hand page explains the operation and offers a brief description of the Honeywell Electronic Air Cleaners installed in the building.

Fifty readers of *The Engineering Journal* were asked to evaluate the advertisements in the November issue from the viewpoints of ACCURACY—INFORMATION and ATTRACTION. Certificates, certifying as to the decision of the fifty man jury will be awarded to Mr. K. K. Warne, Merchandising Manager of Honeywell Controls Limited and to Mr. A. D. Black of Cockfield, Brown & Co. Ltd., Toronto, the advertiser's advertising agents.



E.I.C. CERTIFICATE OF ADVERTISING MERIT

WINNING ADVERTISEMENT

The two page black and white advertisement reproduced above was judged the "best" from the viewpoints of ACCURACY—INFORMATION and ATTRACTION by fifty readers of *The Engineering Journal.* Each month the Institute asks fifty readers to evaluate the advertisements in the various issues from these three viewpoints. This is the second time the company has won the award during a 12 month period.

Plan now to attend

THE KINGSTON REGIONAL TECHNICAL CONFERENCE

Time: May 7, 1960

Place: Kingston, Ontario

Topic: Various aspects of automation and control of interest to Civil, Mechanical, Chemical, Electrical and Military Engineers.

Papers: Six papers will be given (two at a time).

General: A dinner will be held in the evening. A separate program is being arranged for the ladies.

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THE ENGINEERING JOURNAL

Published by The Engineering Institute of Canada — 2050 Mansfield Street, Montreal 2, Quebec, Canada

President: J. H. Hanna, M.E.I.C. Treasurer: G. N. Martin, M.E.I.C. General Secretary: Garnet T. Page, M.E.I.C.

March 1960
vol. 43 no. 3

Cables: Enginst-Montreal
PRINTED IN TORONTO
Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, Post Office Department, Ottawa.

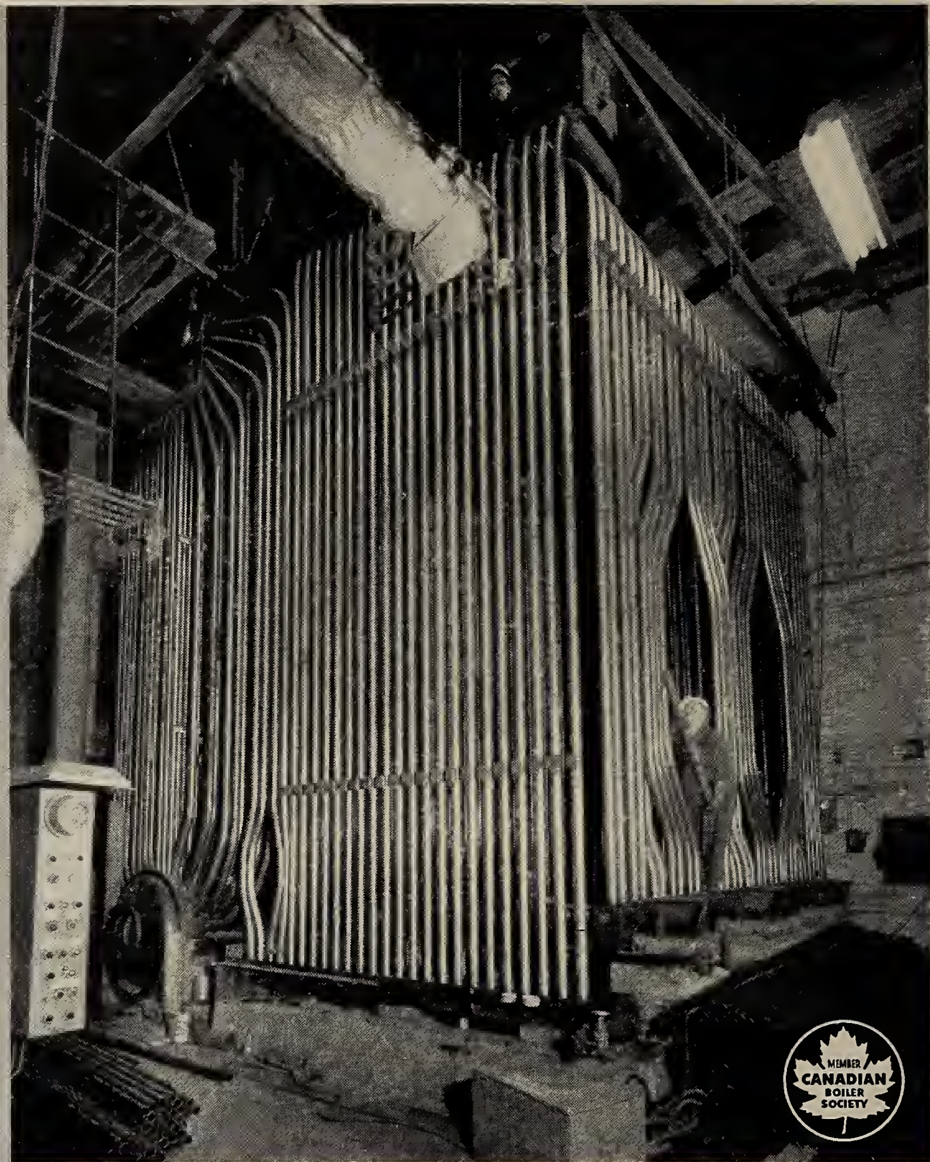
MEMBERSHIP

BNA CCAB

Indexed in
The Engineering Index
The Applied Science and Technology Index

(35,080 copies of this issue printed)

McGILL UNIVERSITY INSTALLS A THIRD DB BOILER



For the past 15 years, two Dominion Bridge steam generators, each having a capacity of 35,000 pph. have supplied most of the steam requirements at McGill University, Montreal. New buildings have been added requiring additional steam capacity and another Dominion Bridge steam generator is being installed to fill this need.

The "D" type boiler, shown here during construction, is designed for an output of 100,000 pph. and a pressure of 250 psig. The steam atomizing burners use No. 6 fuel oil and provision has been made for conversion to gas. Induced draft fan and high stack are unnecessary as the unit is designed for pressurized firing. Heat recovery equipment, in the form of a tubular air preheater is not shown in the picture.

Write for full information on DB boiler products.

boiler products by
DOMINION BRIDGE
FOURTEEN PLANTS—COAST-TO-COAST

26

MEET THE AUTHORS

B. E. Ohlson, B.Sc. '26 (Stockholm), Vice-President, Electrolux (Canada) Limited, Montreal, *(Industrial Design in Canada).*

After a brief period with the Bell Telephone Laboratories, Mr. Ohlson joined the development and sales engineering staff at The Tinius Olsen Testing Machine Company and specialized in dynamic balancing machines. He was appointed to his present position with Electrolux in 1936. He is a member of the Canadian Standards Association, the Canadian Manufacturers Association and over the past years has participated in the National Conventions of the American Society of Tool Engineers. Mr. Ohlson is also the holder of a number of patents.

R. D. Page, M.E.I.C., D.L.C., A.F.R.Ac.S., Nuclear Fuel Engineer, Fuel Development Branch, Atomic Energy of Canada Ltd., Chalk River. *(The Test Rigs and Facilities at Orenda Engines Limited, Nobel Test Establishment).*

After graduation Mr. Page joined the Bristol Aircraft Company, Engine Division in Gloucester, England. He came to Canada in 1954 as an aerodynamics test engineer at Orenda Engines' Nobel Test Establishment.

T. A. J. Leach, M.E.I.C., B.Sc. '38 (Sask.), Chief, Hydraulic Investigation Division, Water Rights Branch, B.C. Department of Lands and Forests *(Engineering Studies of the Fraser River Basin).*

Following an initial appointment with the Prairie Farm Rehabilitation Authority, Mr. Leach served overseas with the R.C.E. and later joined the Saskatchewan Department of Highways as a Resident Engineer. He has been with the B.C. Water Rights Branch for the past 12 years.

Robert A. Campbell, M.E.I.C., B.A. (Loyola), B.Eng. (McGill), Manager, Development Division, Transportation of Aluminum Company of Canada Limited, and Director of The Roberval and Saguenay Railway *(Aluminum in Rolling Stock; Hopper Cars on the Roberval and Saguenay Railway).*

Mr. Campbell has had wide experience across Canada in the Alcan Sales Department. He is a member of the American Society of Mechanical Engineers, the Corporation of Professional Engineers of Quebec, and of several transportation groups. Mr. Campbell has presented papers to the Nova Scotia Mining Society, the ASME (Railroad Division), and the Newfoundland Branch of the Canadian Institute of Mining and Metallurgy.

W. F. Campbell, M.E.I.C., Manager, The Roberval and Saguenay Railway Company, Arvida, Quebec *(Aluminum in Rolling Stock; Hopper Cars on the Roberval and Saguenay Railway.)*

Mr. Campbell's engineering career has included association with the Reid Newfoundland Company; the International Paper Company; the consulting firm of Lee & Nash, Brantford, Ont.; and the Aluminum Company of Canada. He is a member of the American Concrete Institute, the American Railway Engineering Association, and the Association of Professional Engineers of Ontario.

D. G. Breckon, B.A.Sc. (Tor.), Superintendent, NRX Reactor Branch, Engineering and Operations Division, Atomic Energy of Canada Ltd., Chalk River *(Nuclear Research Reactor Operations).*

Mr. Breckon has been directly associated with the operation of the nuclear research reactor, NRX, at the Chalk River Project since he graduated in 1946.

G. W. Govier, M.E.I.C., B.A.Sc. (UBC), M.Sc. (Alta.), Sc.D. (Michigan), Dean of Faculty of Engineering, University of Alberta *(Interpretation of Rheological Data for Engineering Use).*

Dr. Govier has been on the staff of the University of Alberta since 1940. Prior to his present post he was the Head of the Department of Chemical and Petroleum Engineering. He is the author of some 25 technical and scientific papers on problems related to the natural gas industry. Deputy Chairman of the Alberta Oil and Gas Conservation Board, Dr. Govier is also a member of the Chemical Institute of Canada, the Canadian Institute of Mining and Metallurgy, the American Institute of Chemical Engineers, and a past president of the Association of Professional Engineers of Alberta.

R. L. Raikes, M.E.I.C., (London University '32) Director, Lewis, Lane and Company Ltd., Consulting Civil Engineers, Sudbury, Ont. *(A Note on Rainfall Data Analysis in Ceylon).*

Mr. Raikes worked in the U.K. prior to 1951. For the next seven years he was concerned entirely with water resources development in Africa and Asia for the government of the Sudan and for the Food and Agriculture Organization of the U.N. He joined Hunting Technical and Exploration Services Ltd. as water resources engineer in 1957 and later became a Water Resources Consultant in Toronto. He is a member of the Institution of Civil Engineers and the Association of Professional Engineers of Ontario.

R. L. Walker, M.E.I.C., B.A.Sc. '50 (UBC), Chief Water Resources Engineer, Hunting Survey Corporation Limited, Toronto, *(A Note on Rainfall Data Analysis in Ceylon).*

Mr. Walker was assistant engineer, Drainage and Irrigation Department of Malaya before joining the Fraser River Board in 1953. He was later in Ceylon on a Columbo Plan project as water Resources Engineer and Field Survey Chief, Photographic Survey Corporation Limited.

C. H. R. Campling, M.E.I.C., B.Sc. '44 (Queen's), S.M. '48 (M.I.T.), Associate Professor, Department of Engineering, Queen's University *(Accreditation for Canadian Engineering Curricula?).*

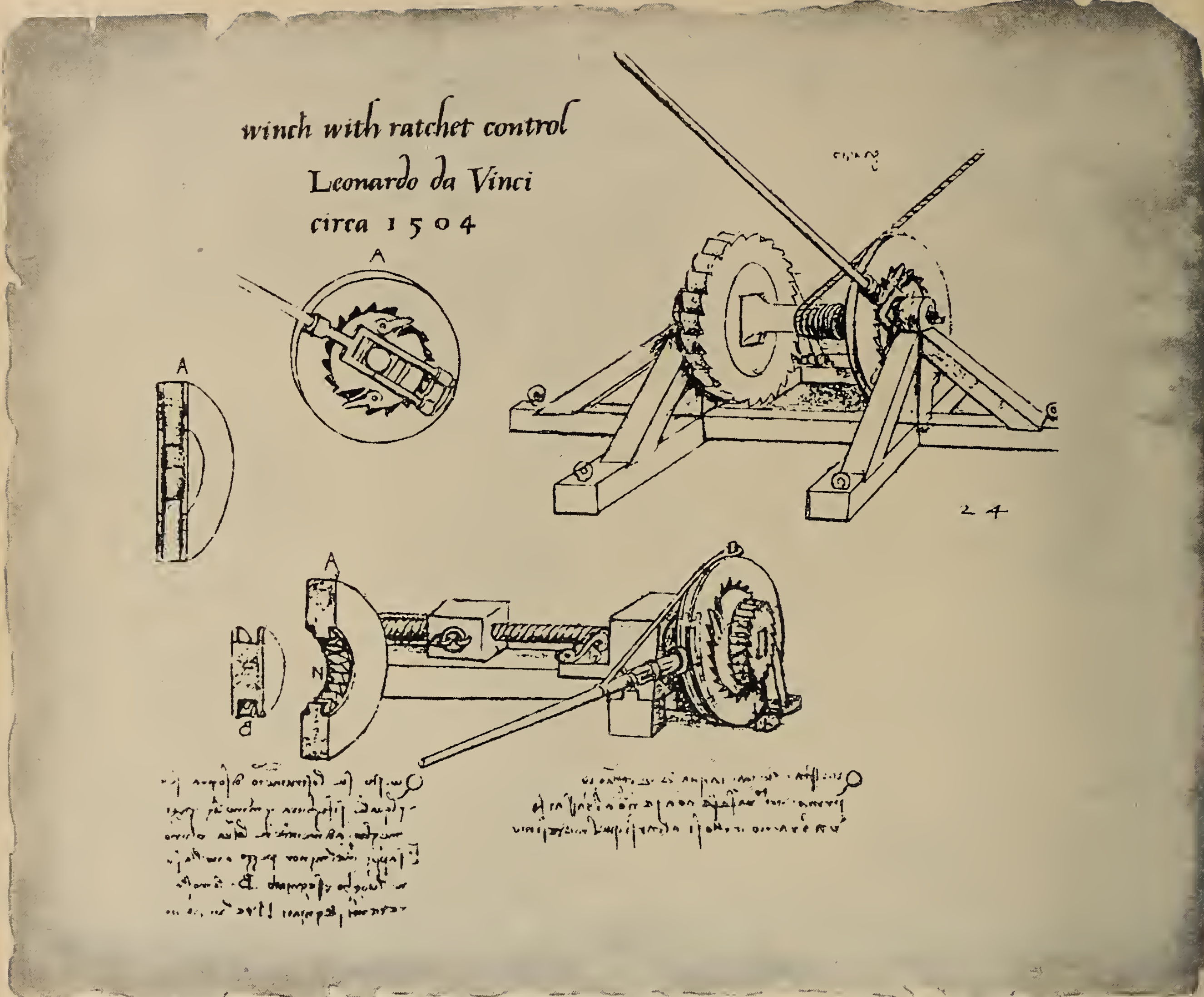
Following his degree from M.I.T. Professor Campling engaged in research at the National Research Council and subsequently taught at the Royal Military College until he joined Queen's in 1955. He is a past president and councillor of the Kingston Branch of the E.I.C., a member of the Association of Professional Engineers of Ontario, the Institute of Radio Engineers and the American Institute of Electrical Engineers.

R. A. Frigon, M.E.I.C., B.A.Sc. '40 (Ecole Poly.), M.Sc. '41 (M.I.T.), Chief, Engineering and Equipment Division, Foreign Trade Service, Department of Trade and Commerce, Ottawa *(Engineering for Export).*

Mr. Frigon has been Scientific Attaché at the Canadian Embassy in Washington, D.C.; on the staff of the United Nations Technical Assistance Administration in New York; with the National Research Council, and with the Harbours and Rivers Branch of the Department of Public Works.

COVER PICTURE

A 45,700 h.p. pump-turbine runner hub assembly at Niagara *(photo: courtesy of English Electric Company of Canada Limited).*



Leonardo Da Vinci possessed what was possibly the greatest diversification of talents of any man in history. Besides being an artist, he was also an engineer and inventor. Reproduced here are original Da Vinci sketches for a winch with ratchet control.

DIVERSIFICATION

Diversity, together with versatility and ingenuity, are among Canadian Vickers' most valued assets . . . and in building fine mining equipment, like the massive jaw crusher illustrated below, Canadian Vickers again displays the range and diversification of its engineering skills.

Equipment and machines, large and small, for every imaginable industrial need, are designed and manufactured in Canadian Vickers' shops, thus fulfilling their pledge: "If Industry Needs It . . . Canadian Vickers Builds It . . . Better."

Hydraulic Machinery • Industrial Boilers • Chemical Process Equipment • Special Machinery Equipment • Ships • Pulp and Paper Equipment • Mining Equipment • Marine Equipment

CANADIAN VICKERS LIMITED

MONTREAL • TORONTO

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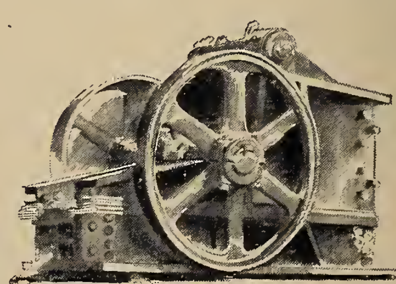


Jaw crusher, built by Canadian Vickers Limited for the Canadian mining industry.

INDUSTRIAL DESIGN IN CANADA

B. Erik Ohlson

Vice-President, Electrolux (Canada) Limited, Montreal.

An address delivered before a joint meeting of the Montreal Branch of the Engineering Institute of Canada, and Montreal Chapter of the American Society of Tool Engineers on January 20th, 1959.

AT THE OUTSET, it might be useful to analyse the title of this paper and its true meaning. It would therefore not be surprising to find that either the term **Industrial Design** is not clearly defined or else it is given different interpretations even by those who are directly active as Industrial Designers. In the layman's mind, the Industrial Designer is one who is primarily interested in creating or planning the external shape and form of an object, without giving much thought to the design of its functional part. This meaning of Industrial Design seems to agree with the definitions applied by the Ilsley Royal Commission on Patents, Copyrights and Industrial Designs. The report of this Royal Commission recommends that patents for industrial design should only be granted for new and in themselves useless shapes, or for patterns applied to industrial objects. If an original-appearing design or pattern should happen to combine with some useful function, it would be disqualified from design patent protection under the proposed new act. An almost opposite definition appears in a recent issue of a trade journal 'Product Design and Materials' October 1958 issue, in which the following appears: "Industrial Design concerns itself primarily with the design of products for large quantity manufacturing and is involved with the functional problems as they relate to performance, the materials, manufacturing processes and merchandising techniques." The professional industrial designers of Ontario have a more comprehensive definition. In their charter, the statement of Aims reads as follows:— "The term **Industrial Designer** is defined to include professional practitioners of industrial design engaged in designing, with regard to consumer acceptance, convenience, fitness to purpose, appearance and safety, diversity of product for machine and mass production, and in applying similar design thinking to the relation of appearance, function, and structure in packages, and other physical manifestations of business enterprise." It seems reasonable to conclude that Industrial Design relates primarily to pleasing form or appearance, external arrangement of functionl parts, ease of use, colour, etc., and that Industrial Design must go hand in hand with Engineering Design which is mostly concerned with the design and arrangement of the functional parts with particular consideration to service, life, quality, selection of materials and ease of manufacture and method of manufacture. A member of a large industrial design consulting association in Toronto described these functions very well. He said: "The Industrial Designer works from the outside-in, whereas the Engineering Designer works from the inside — out". The combination of Industrial Design and Engineering Design could possibly be termed Product Design-Engineering.

The profession of the Industrial Designer gained prominence in the United States in the early 1930s. Some of the more successful designers became very well known, and the association of their name with a product had a great influence on the merchandising success, much as the signature of a famous artist creates particular value in a painting or sculpture. There was probably very little or no industrial design activity in Canada at that time, and it was only after the last war, when the expanded Canadian Industrial capacity had to be converted to production of peace time goods, that the interest in and need for Canadian Industrial Designers became apparent. For this reason, the Canadian Government sponsored the organization of the National Industrial Design Council (N.I.D.C.) which was established in 1948 for the purpose of stimulating the Canadian manufacturers' interest in developing Canadian industrial designers to create products for manufacture in Canada. The Council has since been supported by the Canadian Government by means of a yearly grant and it embraces members from across Canada representing manufacturers, retailers, research officials, educationists, designers and consumers. N.I.D.C. has been very successful in stimulating and promoting the use of Canadian designing talent for all types of manufactured goods. This has been done through exhibitions of Canadian designed products throughout Canada, through films dealing with industrial design, and through competition for N.I.D.C. design awards. It is believed that the N.I.D.C. design awards have done more than anything else to create general interest in Canadian designed products inasmuch as these awards are granted for outstanding design in consumer goods of Canadian manufacture. It should be noted, however, that they are not limited to articles of Canadian design. Designs awards are divided into three main categories of goods, based on usage:

1) PERSONAL Such as luggage, musical instruments, sporting goods, photographic supplies, equipment, toys, etc.;

2) HOUSEHOLD Including appliances, such as radio and television sets, housewares, vacuum cleaners, polishers, cooking utensils, furniture, lamps, lighting fixtures, etc.;

3) OFFICE and INSTITUTIONAL Such as business machines, of-

fice equipment and fixtures, etc.

To enter this competition for Design Awards, manufacturers submit an entry form to the N.I.D.C. committee, with photographs or drawings, explaining the function, colour scheme; or a production sample of the article might be forwarded with the entry. These entries are sent to N.I.D.C.'s headquarters in the Design Centre, Ottawa where they are first screened by the N.I.D.C. Index Committee, and the articles selected by this Committee are passed for final judgment in each category by a jury of four or five qualified and outstanding Canadians, on the basic principle that an article of good design is easy to look at, easy to sell and easy to use. Design Award rating is based on Form—pleasing appearance and good taste. Function—suitability for purpose. Originality—basic improvement on designs. Good value — simplicity, usefulness and price. The winning designs receive from N.I.D.C. a certificate for excellence in design and are given wide publicity. In cases where the designer of an award winning product resides and practises in Canada, he also receives a special Award Certificate which he may use for personal publicity. All winners are illustrated in a Design Awards booklet. All entries which are accepted for consideration but do not win an award are listed and published in the Canadian Design Index. The first Design Award Certificates were awarded in 1953, and the results of last year's competition were announced in May 1958. It might be interesting to compare the number of entries and awards in these two years. In 1953, there were about 300 entries. In that year, 46 Canadian manufactured products received awards, and of these 46, 37 or about 80% were designed in Canada by Canadians. In 1958, there were nearly 600 entries by 140 manufacturers, and 67 products received design awards. Of these 67, 63 or 94% were designed by Canadian designers. The healthy increase in Design Awards, as well as in Certificates to Canadian designers, is a tribute to the good work done by the N.I.D.C. and all its supporting organizations, such as the Association of Canadian Industrial Designers, the Canadian Manufacturers Association, Canadian Retail Federation, the Engineering Institute of Canada, Primary Textiles Institute, the Royal Architectural Institute of Canada, and many others.

Generally speaking, there were no professional Industrial designers in Canada at the end of the last World War. There probably were many

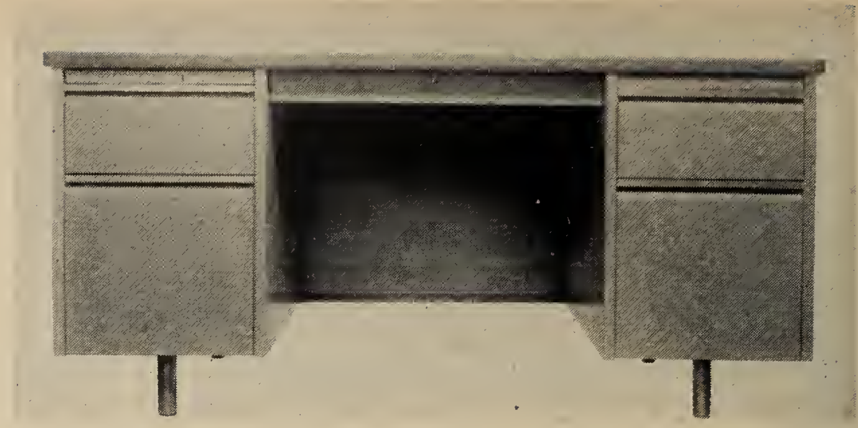


Fig. 1 One of a new line of steel desks, designed in Canada, known as "Strata" furniture.

Canadian-designed products at that time, but these were mostly created by production men or staff personnel who had no formal training in Industrial Design. This does not imply that it is not possible to create a good new design without formal training. In any profession, it is not unusual to find someone gifted with natural talent who is exceptionally successful in new undertakings. But the majority of these early Canadian designers were not very original in their creations and they were relying on adaptations of other successful designs, mostly of U.S. origin. The professional industrial designer found a receptive field in which to work when the war-born Canadian manufacturing plants had to convert their manufacturing capacity into production of consumer goods, and the number of people in the profession increased quickly. A nucleus of designers formed the Association of Canadian Industrial Designers (A.C.I.D.) in 1948. Membership in this Association is based on strict qualifications and limited to resident practicing designers. Membership is open to any creative designer of mass produced products. Prerequisites for election to membership are:

1. Five years' practical design experience;
2. Accomplishment of designs for a minimum of three substantial products which have been reproduced in quantity (500 or more) by industrial processes;
3. Standards of design to conform with those set by the A.C.I.D.;
4. Graduates of a school of design recognized by the A.C.I.D. will require only two years of practical design experience, and two products as above;
5. Two years' continuous residence in Canada.

Application must be made to—The Membership Committee, Association of Canadian Industrial Designers. The initials A.C.I.D. after a Canadian designer's name indicate that he has fulfilled these requirements and is fully competent to act as a consultant or staff designer in the creation of new products for commerce and industry. At the present time, there are about 50 members in the A.C.I.D., of whom 35 are staff designers and 15 consultants; most of these consultants own or operate their own firms very successfully. Many of the A.C.I.D. members have been very active in furthering the status of the industrial designer in Canada, partly through their cooperation in the work carried on by the N.I.D.C. The A.C.I.D. recently celebrated its tenth anniversary, and in this short period of ten years many of these Industrial Designers have become famous for their design work —not only in Canada, for they have also won respect and recognition internationally. Many have won awards for their designs at exhibitions in Milan, Brussels, Paris, London, etc. One off-shoot of A.C.I.D. is a recently organized association of Professional Industrial Designers of Ontario. A similar association is under consideration for the Province of Quebec. From the foregoing it is quite evident that Industrial Design by Canadians for Canadians, as well as for export trade, has been very successful. Activity in this field has grown more or less in step with the growth of Canada as an industrial nation.

The big impetus came, as already mentioned, with the sudden growth of the industrial plants during the war period. The end of the war left this industrial capacity with sudden cancellation of war contracts and with very little preparation for switching to production of consumer goods. The shortage of goods in general and the pent-up demand made it rather easy to satisfy the public requirements in design. Imitation of any saleable line was quite acceptable. There was very little competition from imported goods as all countries had a similar shortage and demand for consumer goods. As the demand gradually lessened, the Canadian manufacturer found foreign competition particularly from the United States, taking a great deal of the Canadian business. This developed into a shortage of U.S. dollars in Canada, and import restrictions became a necessity. In turn the Canadian manufacturer had the chance to develop his own line of products, and Canadian Industrial Designers thus became a necessity. Canadian manufacturers and retailers discovered that there was a need for products designed to meet Canadian conditions, Canadian tastes and Canadian production facilities.

The buying public is probably more educated or aware of good design today than it was ten years ago. Canadian designers appear to be of divided opinion on what constitutes the main difference in design requirements in Canada as compared with the United States, or in what respect the Canadian buyer differs from the U.S. buyer. Similarly opinion appears to be divided as to what influence the ethnological background and culture of the French-Canadian and the English-Canadian population has had on taste or preference in styling. It is generally agreed among Canadian designers that the Canadian buyer is more conscious of better quality and good service than the U.S. buyer. This could be because the average income of a Canadian is considerably lower than that of the American when measured as hours of work required to purchase a product. Consequently, a Canadian will be more cautious in his selection of goods, and quality is of more importance than appearance. The product must give excellent service for a longer period of time. He cannot afford to replace the article for a new model or design as frequently as his friends south of the border. There is less agreement between Canadian designers concerning the Canadian's taste in style or appearance. Some designers hold that the Canadian's taste leans a little more towards simplicity in design and less towards the flashy decor that American designs usually offer. One designer of T.V. and radio sets, who has considerable experience in designing for Canadians, is of the opinion that the Canadian product needs more glitter than the U.S. styles, but this requirement is limited to sets in the lower price ranges. There is also divided opinion among designers regarding the influence of the various social cultures in Canada on the styling and design of a product. There is probably a qualified difference in taste between these social groups which is influenced not only by ethnological and language factors but possibly to a greater extent by geographical distribution of population and traditions. The geographic difference is more distinguishable in the furniture market, according to one designer in the Montreal area who is very active in the design of this product. He compares the development of customers' style preference with the ladies' dress and garment business. Here, the new styles are mostly created by the big couturier houses in Paris. Copying of new styles is very common as there is little or no possibility of design protection in this field. New York manufacturers follow the style trends by studying and copying the Paris creations. The Montreal manufacturers follow the trends in New York and smaller cities around Montreal follow the styles adopted by the Montreal manufacturers. The new styles are first offered and accepted in the biggest population concentrations and gradually spread to the smaller communities. For this reason the big city dweller seems more sophisticated and advanced in his taste than the farm population, who would be the farthest link in the transmission of the new styles. There does not seem to be much disagreement amongst Canadian Designers that the Canadian buying public is greatly influenced by American design trends. Practically all American magazines with their colourful advertisements of American products are read in Canadian homes. Similarly, their radio programs and T.V. shows with all the powerful selling messages are seen and heard in Canadian homes. Many of the Canadian manufacturing plants are owned and controlled by Americans or American parent companies with a reported 40% of Canadian business thus controlled. It would seem only natural that such companies, having access to ready-made American product designs, should take advantage of this fact instead of developing special Canadian designs. Fortunately, this policy is not generally adopted by American controlled industries in Canada. As a matter of fact, there seems to be a tendency for the Canadian subsidiaries to 'go it' on their own, and many large companies have industrial design departments of appreciable size which have developed very successful Canadian designs, produced not only in Canada, but frequently also adopted for production in the United States. Nevertheless, the close economic ties with the U.S. are bound to have a great influence on the Canadian product designs, as the successful Canadian designer needs to be quite aware. They are too strong to be overcome by the virtues of Canadian designers' own ideas of what constitutes good design.

Fig. 3 Dresser of Canadian design and make.

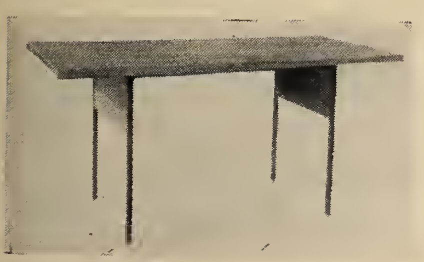


Fig. 2 Working Table designed and made in Montreal.

To what extent is the consumer's preference related to the design of a product? Does the designer create to an established taste or does he create and influence consumers' preferences through his designs? It might be unrealistic to talk about the consumer's preference in styling a product. It seems clear that the style preference does not originate with the consumer, but rather this preference has been developed and conditioned in the consumer through advertising and selling slogans, etc. The consumer at large is more apt to buy an article because it is like the Jones's, because it gives him prestige and superior standing in the community, or because it has "sex appeal", than because of his own considered judgment. The Industrial Designer must keep this in mind and his own educated taste for beautiful lines or appealing form can only be applied to new product designs at a very gradual pace. If the design concept is too far ahead of public acceptance, there is danger that the product will be an unsaleable failure. Many prospective buyers would hesitate to choose a product which is drastically different from the conventional because they are afraid of unfavourable judgment of their own taste by their friends or neighbours. The design of an article can be a little more drastic in styling when it is intended for the luxury buyer. The most expensive models can be sold to a more sophisticated clientèle. The styling of these expensive models can serve as fore-runners or pace-setters for future designs of the mass market models. A design created by a famous industrial designer can also deviate a little more from the accepted, inasmuch as the fear of being considered a 'goof' when buying his creations is much reduced by the generally expected acceptance of his work. This fear of making a mistake in choosing a product design extends to the manufacturer, who often will commission the famous designer to create his new products in the belief that this will eliminate or greatly reduce the chance for a 'dud'. It has been said that of all new products on the American market, about four out of five are commercial failures. It is also interesting to note that about 70% of new products are originated by small companies. Could it be that the small company does not have the means of publicising these new products as effectively as the big company and promoting the new ideas involved to the extent that public acceptance is accomplished. Or, on the other hand, is it possible that the small company does not have the qualified staff designers or does not avail itself of the services of design consultants, so that the new designs it creates are not approved by the buying public because they suffer from inadequacy in styling or performance. The major changes in styling trends are more successfully launched by the bigger corporations on account of their established prestige and their more powerful and widespread sales promotion. A good example of such style change is the new trend in refrigerator styling and other home appliances. The squared box effect or the "sheer" look was sold by a large U.S. manufacturer through extensive T.V. advertising in which the "sheer look" was demonstrated by the angled hands and arms of a beautiful girl. The smaller companies' new designs would probably have a greater chance for success if their designs were carefully planned to agree with current style trends. The technique of "Motivation Research" attempts to probe the depths of the consumer's mind in order to determine the reasons—conscious or sub-conscious, which make a consumer buy or not buy a product. The industrial design behind a product in particular as it relates to appearance, is important, not necessarily because the styling is in good taste from the Industrial Designer's own point of view, but because it appeals to the consumer's sometime sub-conscious desire to satisfy some basic emotional requirements. The human being does not always confess to vanity or egotistical traits. An individual who is asked what he would like to get in a product, for instance, quality and service as opposed to fancy styling, will often say that he prefers quality and service. When it comes down to buying, however, the consumer often buys the goods for appearance's sake. It is possible that the continued educational effort of the National Industrial Design Council will eventually have the desired effect of influencing the buyer to give more consideration to quality and simplified and refined styling.

In this connection, it is interesting to consider the automobile designs. For years the styling has been streamlining. The car is getting lower, longer and in all respects, is built to indicate speed—the speed of the airplane, where streamlining is of definite and practical importance. Lately, the styling of automobiles has tried to simulate speed by adding fins—here obviously capitalizing on today's preoccupation with supersonic speeds and rockets. It is doubtful whether streamlining or fins has any practical influence on the performance of the automobile, but it sells the car just the same—it satisfies some human desire for more and more speed. There has been much talk about the consumer's requirement for a smaller, more economical and efficient automobile: smaller for easier manoeuvring in city traffic and parking, less powerful engines for better mileage economy, and a more practical exterior for less costly repairs, etc. The small car is produced in Europe and is available in Canada and the United States at relatively low cost. It is interesting to observe that the percentage of small cars purchased in Canada is almost twice that in the United States. The larger American automobile companies are very dubious that a small car can compete with the flashier big ones. The fact that the small car has greater acceptance in Canada would tend to support the claim that the Canadian buyer is more conscious of value than the U.S. buyer, and it indicates the difference in economy prevailing in the two countries. The streamlining of automobiles has been carried over into the design of other articles where streamlining has no possible functional value. This sort of style transfer has been very much in vogue. Consumers have appeared completely satisfied that style and ostentation are of greater importance than fundamental design, sound engineering and reliable performance. They have been more conscious of fashion than of solid workmanship and sound quality. There is much discussion in the U.S. about the merits or demerits of the teachings in the so-called theory of "planned obsolescence". This doctrine attempts to increase the turn-over of goods by purposely making the product inferior so that it will have to be replaced after a short period of use. Frequently, the maintenance is so difficult and expensive

Fig. 4 Canadian designed coffee table.

that it is easier to replace the product completely. Planned obsolescence is also the policy of bringing out re-styled products every year in order to make last year's model old-fashioned, out of date and obsolete. Some American designers consider that planned obsolescence is good for the economy of the country, whereas others think that the public is beginning to tire of poorly designed and engineered products and is refusing to buy them. There is an indication that this trend to gadgetry in U.S. design is on the wane and that the consumer is revolting against poor quality goods by refusing to buy. The Canadian buyer who always has been interested in more value is probably ahead in this trend. Although Canadians are greatly influenced by American trends in design, do Canadians use better judgment in the selection of automobiles, appliances or furniture? Do Canadians have better taste for the sounder designs or stylings? Are the emotional requirements, which motivate their choice, any different from those of the American? Is there any real difference in product requirements in Canada which can be better interpreted and defined by a Canadian Industrial Designer? There are some very fundamental differences but these are not too obvious if we think of Industrial Design only in terms of styling and appearance. In one case a Canadian furniture manufacturer commissioned a famous U.S. industrial designer to develop for him new furniture stylings. The designs were obtained at a considerable expense, and they were probably very good, but they were never put into production. They were too expensive to produce in the quantities which a Canadian manufacturer can expect to sell. It is likely that an experienced Canadian Designer would have understood this and designed to suit the more limited market. The Canadian Manufacturers' Association has worked very diligently to promote a preference for Canadian products through a "Buy Canadian" publicity program. This is a very sound and deserving effort which should be supported by all Canadians as much as possible. The choice of a Canadian product will be natural when the product has special customer appeal, and the "Buy Canadian" habit can be greatly furthered by Canadian Product Designs that can be efficiently and economically produced in small quantities and still be very competitive with imported products. Appreciation of the value of our own products and confidence in the Canadian Designers' creative qualifications would stimulate the development of new Canadian products that would be preferred on their own merit. "Buy Canadian" would then become a natural consequence because of special value, and less of a patriotic gesture.

Fig. 5 Executive Desk.

The Canadian Designer should understand the production capabilities and limitations of Canadian plant in order to design for economic small quantity production. This is where co-operation and agreement between the Designer-Stylist and the Design Engineer is of great importance. The stylist may sometimes propose constructions which are too difficult to produce, but usually there is a solution or compromise to make possible economic manufacture, and to this end co-operation with the Design Engineer must be developed. When production volume is limited, as it must be in Canada, it is most necessary to design products which can be produced at reasonable cost despite low volume. This takes greater ingenuity, experience and effort, if the Designer must cope with these limitations than if he does not have to worry too greatly about the need of special equipment or involved tooling. It is in this area that the Industrial Designers' work becomes wider in scope to include all or most phases of product engineering, or product planning. The Canadian Designer through this wider application should be better suited to create new designs well suited for Canadian manufacture than one unfamiliar with local conditions. What kind of consumer products are best suited for design and manufacture by Canadians? There are naturally certain conditions in Canada which have an influence on the kind of product that should be produced and sold here. First, of course, there are articles which through climatic conditions, customs, or living conditions, have a sizeable market in Canada but meet little demand elsewhere. One such article, for instance, is the electric tea kettle. This appliance has won a wide acceptance and achieved good sales volume in Canada, whereas the demand is relatively limited in the United States. The reason must be that tea is a beverage widely used in Canada, whereas Americans prefer coffee. Another factor which should be borne in mind by the Canadian Designer is, of course, the extent to which the product should offer superior quality. As the Canadian average income is lower than that of the United States, it is to be expected that the Canadian buyer will look for better value. The philosophy of design for obsolescence should not be applied in Canada but rather an effort to combine durability and quality with appealing appearance. How should the Canadian Designer go about creating a new product and what factors must be considered? First, it must be understood that business is organized and companies are formed for the one ultimate purpose of making a profit on invested capital. Without profit, it is impossible for a business establishment to exist. Therefore the most important aim behind the planning of a new product is to create something that can be economically produced and will be attractive and useful to the consumer. This will sell in large enough quantities to permit the return of the investment in a reasonably short period of time. Profit cannot be realized before all investments and costs have been absorbed. The time during which these costs should be absorbed depends greatly on the nature of the goods and on competitive practices. In some cases all investments must be absorbed in one year, in other cases maybe five or ten years can be allowed. Thus the manufacturer who wishes to stay in business must have a reasonable assurance that the new product will be a market success at a price that will assure his distributors a profit margin as well as a reasonable return on the investment. The evaluation of the degree of consumer acceptance can be obtained from the selling force—from Sales Manager to Dealer—and also directly from the prospective customer, through various methods of market analysis or market research. "Motivation Research" is sometimes part of this investigation.

What is the role of the Industrial Designer in the total span from the creative effort to the final product? The first step in new product planning is of course the collection of ideas for new products. The ideas can come from many unsuspected sources; the need for new things sometimes is first voiced by the customer, or by the dealer or the sales manager, but it can also come from entirely different and unassociated directions—for instance, your toolmaker, serviceman, or any other source, for that matter. So the designer of new products should dip freely into the inexhaustible pool of ideas that occur to everybody at one time or another. The methods of collecting new ideas may vary greatly, but the important thing is that the flow of ideas be constantly stimulated and further developed. Many of the ideas submitted may seem too fantastic, impractical, or ahead of their times. These are many pitfalls in the process of screening the ideas. One of the more dangerous attitudes is to discard ideas because at first they seem too expensive or costly to manufacture. After careful study, it is often found that the production engineers will evolve new methods or tools in order to produce at the desired cost level. An idea for a new product that has interesting possibilities should be carefully studied, first on the merchandising side and secondly on the manufacturing side. It is surprising how often manufacturing difficulties can be overcome by the application of ingenuity and effort, making it possible to reduce cost of the final product and allow an acceptable selling price. After an idea has been approved, it should be further developed and some preliminary models made. A three-dimensional model is much more effective in generating ideas for improvement than a sketch or drawing. This first model could be purely functional, and little time should be given to styling at this point. The worth of the product and its possibilities in the market should again be considered by the sales experts and higher management members, and if it is still approved it should be properly designed for both good appearance and easier manufacturing. Revised models or prototypes are made as the development progresses and the improvements occur. There is some disagreement as to whether the styling designer should set the pace by making the design of the external appearance and arrangement, or whether the design engineer should make the arrangement of the working parts and then let the stylist try to house this arrangement in an appealing external form. The styling specialist who has less direct interest in the processes of manufacturing might be best suited to initiate the design effort because he will not be inhibited by knowledge of what "can't be done". He might make the design engineer's task more difficult, but he provides a challenge which often leads to the development of better techniques and improved materials and manufacturing methods, and tools which in turn tend to result in a better product. The happiest arrangement is when both stylist and engineer work together, allowing for some flexibility and permitting modifications of styling to simplify manufacture or improve performance. At the first stages of the design, it would be well to make a small quantity of the product for testing consumer response and for further consideration by the merchandising experts. This sampling of the customer's response and salesmen's enthusiasm for the product is quite important, as it can rule out unprofitable or unsuitable products, which if put into production on a greater scale could mean sizeable losses for the manufacturer, both in money and prestige. This test might bring out the necessity for further styling or design changes, and suggestions obtained should never be taken lightly. When finally a satisfactory design has been created, both from a functional and aesthetic point of view, the design and production engineers must prepare the necessary specifications for materials and parts involved and determine plans for the best manufacturing processes. Even at this stage there might be conflict, and some flexibility in the design specification should exist. Again, it is a matter of co-operation and some give and take. A very slight change in design might often result in considerable savings in manufacturing costs. Very often, too, the manufacturing engineer can see possibilities for combination of parts, such as integrating several parts into one casting instead of using separate components which might have to be riveted, welded or otherwise assembled. The production specialist or tool engineer is an invaluable adjunct to successful product design. And this is particularly true in Canada, where cost of tools per item produced is all-important.

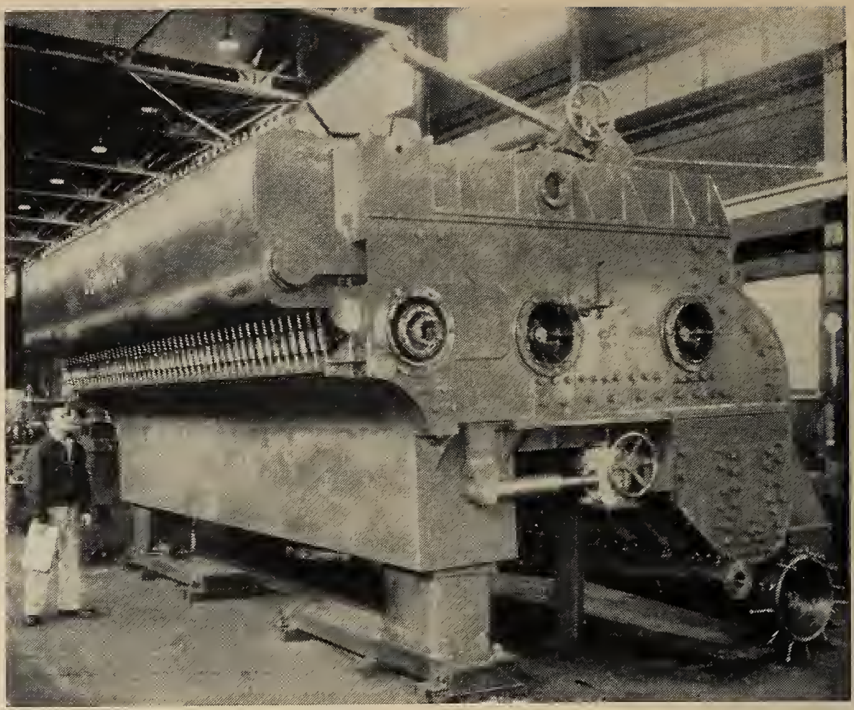
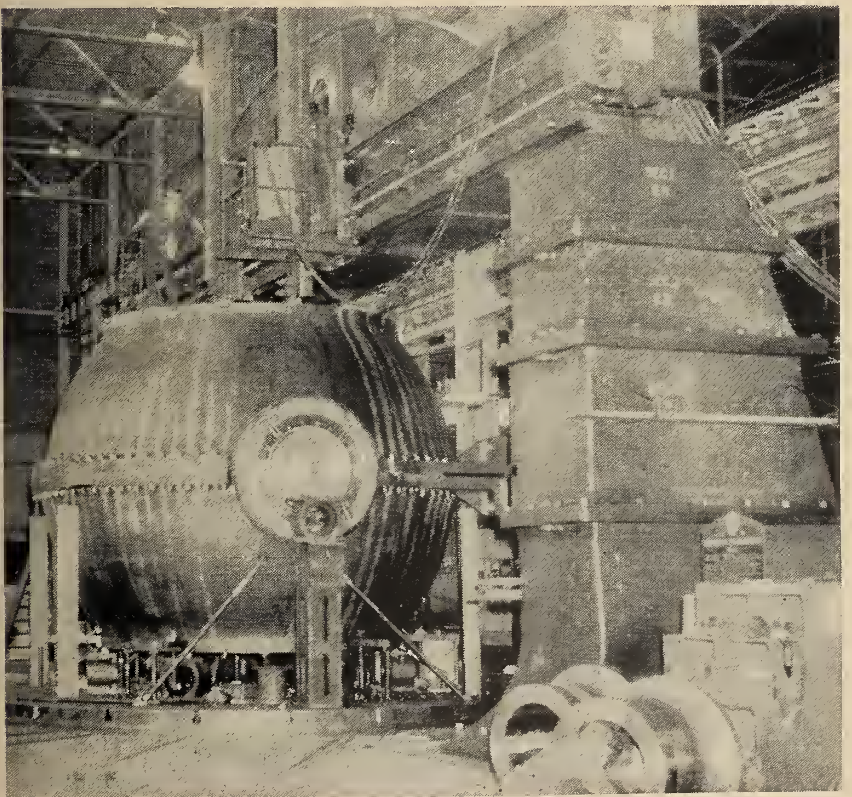


Fig. 6 The original concept of this type of pressure head box was Canadian.

At this point, it is emphasized that the Canadian Tool Engineer has won recognition for his high standard of efficiency and ability. It has been said that "Necessity is the Mother of Invention". This might be particularly true in Canada where tools must do a job as efficiently and economically as those used for mass production in the United States, but production methods must be evolved which require tools costing considerably less. There are innumerable examples of the ingenuity displayed by the Canadian Tool Engineer. Special tools have been made in Canada which perform better and cost less than the tools used for the same job in the United States. An automatic painting machine for painting masked areas was made in Canada for less than $2,000. The corresponding machine for the same job in the United States cost $20,000 and did not work as well. A special coil winding machine which would cost $15,000 to import from the United States was made in Canada for less than $6,000, and it was actually an improvement over the American machine. There are countless examples of what can be accomplished in the simplification of tools when necessity calls for it. A drilling machine was constructed in Canada with air-operated drill feed units at a cost of $7,000., that drills up to 7 holes simultaneously in a casting: the corresponding American made equipment would have cost at least three times as much. During the war years, there was an adaptation made of a drill press that produced a striker for hand grenades as efficiently as an automatic screw machine, which would have cost at least $4,000. as compared to $250.00 for the drill including an automatic chuck and cutting tools. An example of cost reduction that reduced material cost, is the successful development by a Canadian firm of die casting aluminum in 1/16 in. wall thickness. This previously was not considered possible, but the engineers of this Canadian company made it a practical success, thereby saving about one-third of the aluminum content and reducing the weight of the product which also was a distinct advantage to the consumer. This did not in any way impair the required strength of the components involved. Magnesium die castings were considered for the purpose of weight reduction but the success of die casting in aluminum in 1/16 in. wall thickness made this more expensive material choice unnecessary. It is certainly not unreasonable to say that the Canadian Tool Engineer has done more toward economic manufacturing in Canada for successful competition with imports, than any other group of engineers. He has been instrumental in reducing production cost not only in the way of low cost tooling but also through reduced costs derived from design simplification; both conditions dictated by typically Canadian needs. As Canada's per capita dollar value of imports is about five times the corresponding value in any other country and about ten times what it is in the United States, it is evident that the Tool Engineer's contribution towards reducing this value by making manufacture in Canada economically possible, is of the greatest importance to Canada's future.

A prominent Canadian industrialist recently said: "The natural market for Canadian products is the 17 million Canadians in this country — and I say this, without in any way decrying the importance of foreign markets to the Canadian economy. Because we are all consumers, the most telling blow any one of us can deliver against the menace of unemployment is to spend our Canadian dollars on Canadian products". The creation of well designed Canadian products at competitive prices is the best possible means to induce the Canadian consumer to "Buy Canadian". For this reason, it is very important that the Industrial Designer, the Product Designer and the Manufacturing Engineers work in harmony and co-operation instead of taking opposing or even antagonistic attitudes towards each other as sometimes is the case. In the course of the design of a new product which recently appeared on the Canadian market, a rather interesting technique of *Brain Storming* was used. *Brain Storming* is a term applied to a method of creating ideas by free and unhampered discussions in a group of men of varying activities and interests. It is surprising how often a man "cannot see the forest for the trees". With the specialization that is so common today, one is prone to get in a rut and develop mental blocks which subconsciously inhibit one's thoughts and direct them only into certain limited channels. Someone who is not specialized in one particular field of endeavour is likely to take a fresher and more unfettered viewpoint when he is brought to think about the problems related to that particular field. This particular design effort was accomplished by a team consisting of a product engineer, an artistically-minded design engineer, a tool designer and a tool engineer, a service manager, a purchasing agent, a production manager, and a stores manager. The group was led by a co-ordinator who tried to bring about constructive criticism and ideas that related to the product. This active group worked as a team through the various phases of design from the first idea, the prototype stages, the design and material specifications and the manufacturing methods and tool design. At regular intervals the group would be joined by a management sales authority, who would criticise,

Fig. 7 11 ft. spherical valve, among the largest of its kind in the world, designed and built in Canada.



approve or discard the design so far developed, and sometimes other employees who had no direct connection with the development would submit their suggestions. Opinions were also gathered from salesmen and prospective customers. In this way it was possible to arrive at a design that found immediate and enthusiastic consumer approval. It was a top quality product which had many new features, and still was produced at a cost less than the product it replaced. The method closely resembles the concept of "Comprehensive Design Research". This method of Product Planning rightfully assumes that all functions of a business organization must participate and be responsible for the development of new products. This is a very sound approach since all functions have some vital part in the final accomplishments by contributing, factually or physically, to the product during its development stage. To come back to the Industrial Designer's role, it is evident that the profession as such, cannot be entirely limited to styling or external appearances. It must be a part, and perhaps the leading part, of the team that is engaged in planning and developing new products. In Canada, the organization for product planning will probably be informal and involve fewer people than in other countries. There is evidence that the closer cooperation and more intimate personal relations of a smaller group can perform at a faster and more efficient pace than a more formal and involved organization.

The foregoing has been directed mostly to the Canadian design and production of consumer goods. It would be unfair not to mention the outstanding achievements of the manufacturers of industrial goods. We have here in Canada engineering firms which enjoy world-wide recognition for their development and production of hydraulic turbines and associated equipment. One of these companies has research and development laboratories that have improved the efficiency of hydraulic turbines and associated equipment and originated such items as the spherical hydraulic valve. The undeserved lack of confidence in Canadian developments can be noted even in this type of industry. One firm originated and patented the pressure type head box in 1936, to improve the quality of paper and increase the speed of paper making machines. The Canadian paper industry was not then in a position to adopt and experiment with this advanced design of equipment. Subsequently an American firm designed the pressure type head box, but had to make an agreement to pool their designs with the existing patents. Today, almost all paper machines are equipped with pressure head boxes, and old head boxes are being replaced. This again shows the need for more confidence in the soundness of Canadian engineering undertakings. Many Canadian-built machine tools have proven themselves as efficient and well built as any of the imported ones. The papers have given attention to outstanding developments in the aeronautical field: Canadian designed turbo jet engines, landing gears and aircraft. There is lively discussion now as to whether or not the results of one of these aircraft developments should be produced in Canada. Whatever the decision regarding manufacture of this aircraft, the fact remains that its design and development is an outstanding example of Canadian engineering achievement. There are so many industrial goods produced in Canada that it is impossible to name them all here, but the mention of a few seemed appropriate.

The National Industrial Design Council does not give awards for excellence in design of industrial goods. This is probably only because the judging of industrial goods, if entered in a contest, would be too difficult. It would present quite a problem to send a locomotive, or even a crane or a shovel, to the N.I.D.C., and it would be too expensive to send the judges to the location where such industrial machines might be seen and evaluated. Nevertheless, there is great need for "Industrial Designing" in its limited interpretation of styling, even in this field. Even a tractor is easier to sell if its exterior suggests power and stamina and ease of operation through graceful and appealing lines and form, and through the selection of attractive yet practical colours. The use of *Colour Dynamics* in the creation of appealing designs is a very important factor, *Colour Dynamics*, (the science of utilizing colours to influence an individual) is of great importance in the machine tool industry. The working areas of a machine tool are painted in one colour whereas the nonfunctional parts are painted in another. These colour combinations will have the effect of making the worker's task more pleasant and efficient. It has been proven that the selection of colour does have a definite influence on the way the individual feels and responds to his surroundings. The use of pleasing colour combinations is just as important a consideration when designing industrial goods as it is in the design of consumer goods. The application of the qualified designer's training in what constitutes good taste in both form and colour styling, as well as his knowledge of the consumer's ultimate preference, has a great influence on the article's commercial success.

The smaller industries which do not have personnel capable of doing their own product development, would be well advised to get in touch with one of the highly trained and well qualified Design Consultants in Canada. The Canadian manufacturer should have confidence in their proven ability to create new products of excellent design and it is equally necessary that the Canadian consumer display a little more confidence in the Canadian product. By educating ourselves to "Buy Canadian" whenever there is a choice, we would eliminate, to a very great extent, our national problem of unused industrial capacity and unemployment.

If one can be allowed the liberty to stray from the limitations of the given title of *Industrial Design in Canada*, and to cover the broader field of Product Design and Development, certain predictions as to the future of Industrial Design in Canada can be made. In the foregoing, the Industrial Designer has been given the role of the Stylist, Artist and Dreamer, and the Engineering Specialist has been given the responsibility for the functional part of design. Probably this is the part that most Industrial Designers have taken in the past. In the future however, the scope of responsibility and activity of the Industrial Designer will widen. He will be a general practitioner in the field of styling, merchandising, market research, motivation research, product planning, engineering design, tool design and production and finance. He will not necessarily be an expert in all these fields but he will be able to coordinate, lead and inspire the various specialists who must play their part in the successful creation of new products. Such versatile talent already is available in Canada: the growth in the Industrial Designer's status should parallel the promising future and progress of Canadian industry.

Acknowledgments

The author is indebted to the officers of the Association of Canadian Industrial Designers and the Canadian Manufacturers' Association, as well as to the officers, staff designers and stylists of several Canadian industries for information contributed towards the preparation of this paper.

THE TEST RIGS AND FACILITIES AT ORENDA ENGINES LIMITED NOBEL TEST ESTABLISHMENT

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Introduction

SINCE THE OVERALL efficiency or a gas turbine varies as the product of its component efficiencies, it is obvious that the individual component efficiencies must be developed to a high level.

It is impracticable to carry out performance development of the components solely by testing on a complete engine, as it is not possible to instrument an engine as fully or as accurately as is necessary. Further, mis-matching of components is not readily apparent on engine testing, as the operation of the components is interdependent, and only one curve on the characteristic family of curves of each component can be explored. Finally, the performance development of an engine is the result of a large number of minor modifications and the effect of each would be largely obscured by other variables on a full engine test.

It is necessary therefore to evaluate these modifications on a test rig permitting analysis of the component in question independently of uncontrolled variables.

The small mechanical components did not pose a major problem, but the compressor for an engine of the required specification would absorb some 12,000 h.p. under ground level intake conditions at full speed, and even under throttled intake, simulated altitude test conditions, it would require a prime mover of at least 4,000 h.p. for rig testing. Further, in order to test a single combustion chamber under ground level conditions an air supply of roughly 15 lb. per sec. and 60 p.s.i. is required.

Fig. 1. Aerial Photograph of the Nobel Test Establishment.

Historical

To design and construct an establishment adequate for testing of this order would obviously take several years and be very costly. Accordingly, several plants available through the War Assets Corporation were inspected. The power plant of the Defence Industries Limited explosive factory at Nobel proved to be the most suitable. (Fig. 1)

This plant was set up in 1940 for the manufacture of wartime explosives. It covered an area of about 2 sq. miles, and at its peak employed more than 4,000 employees. The plant was Crown-owned, built entirely for wartime use, and hence was available with all facilities through the War Assets Corporation.

The power house contained a turbo-alternator of 4,700 h.p. nominal rating; four air compressors each delivering about 3 lb. per sec. of air at a pressure of up to 110 p.s.i., and foundations and connections for a fifth machine; and twelve boilers, eight with a working pressure of 135 p.s.i. and four with a working pressure of 250 p.s.i., each capable of being over-rated to 25,000 lb. per hr. of steam output.

Electric power and water were adequately available. The machine shop was fairly well equipped and of good size. There was space suitable for offices and laboratories.

Housing was available in Nobel Village.

Accordingly application was made to have this plant made available, and in November, 1946, the central facilities, located on some 17 acres of land, were formally turned over to the company.

Description of Basic Facilities

The Nobel Test Establishment is located some 120 air miles and some 173 road miles north of Malton, Ontario, resulting in a driving time of 3½ hr. between these points. The Canadian Pacific Railway transcontinental line and the new Trans-Canada highway both pass through Nobel (See Fig. 2). The Trans-Canada highway is still under construction in some important sections and when completed will reduce the distance from Malton by road to 130 miles. Continuous teletype communication is maintained with the engineering office at Malton.

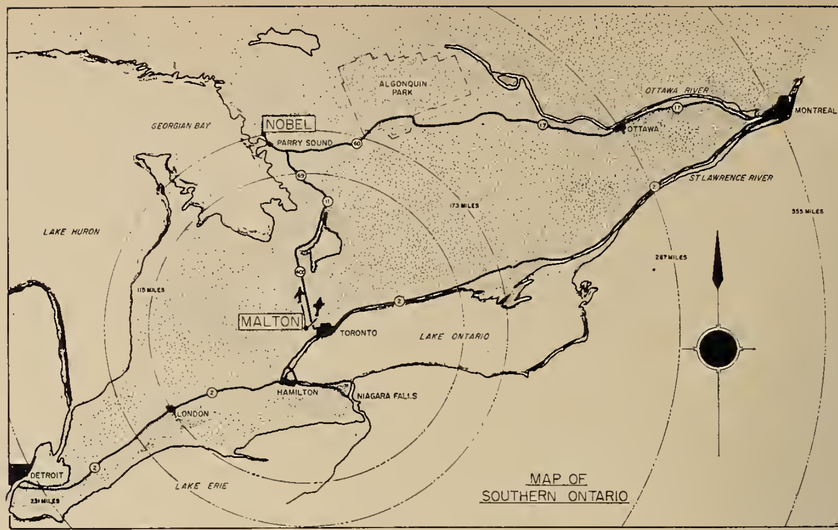


Fig. 2. Map of Southern Ontario.

The plant is about 7 miles north of Parry Sound, and roughly 1 mile from Nobel Village. Its immediate industrial neighbour, ½ mile to the west across No. 69 Highway, is a plant of the Canadian Industries Limited Explosives Division (See Fig. 3).

The Test Establishment covers an area of some 17 acres. This area is substantially level, and the granite bed rock is generally only a few feet below the surface. This is occasionally inconvenient, but on heavy structures foundation costs are minimized.

The plant comprises the power house, new test cells, machine shop, new office, old office, fire hall, assorted smaller buildings, and five buildings retained since the last war for storage purposes by Canadian Arsenals Limited (See Figs. 1 and 4).

Services

Steam: The boiler room contains six boilers each rated at 394 h.p. and 12,800 lb. per hr. of steam. They can, however, be over-rated to 25,000 lb. per hr. of steam.

The four high pressure boilers have a working pressure of 250 p.s.i. and deliver steam to No. 1 compressor test rig, No. 2 compressor test rig, or the ejector of the sector altitude com- boilers operate at 135 p.s.i. and deliver steam to the ejector of the Orenda altitude combustion test rig, the turbine drive of the blower, various auxiliaries, and the plant heating system.

These boilers were designed for a steady industrial steam load; however, test operation demands a rapidly fluctuating load and frequent overload. This necessary abuse naturally tends to shorten boiler life, and is bustion test rig. The two low pressure reflected in an accelerated maintenance schedule.

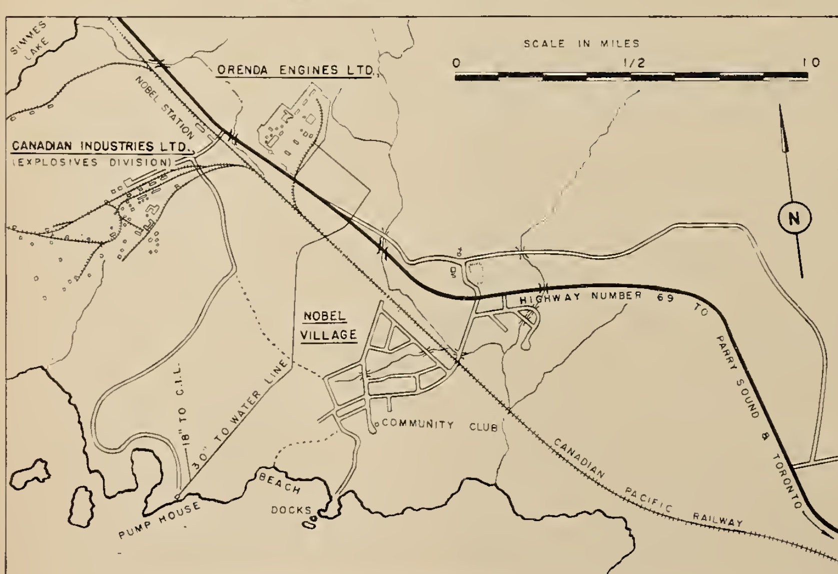
All the boilers have been converted to oil firing in the interest of operational flexibility and economy. The present storage tank capacity for Bunker "C" oil is 60,000 gal. and, as this is sufficient for only four days of heavy testing, the plant is somewhat dependent on rail service for the continuity of its operation.

Air: Compressed air is delivered from a bank of five 500 h.p. compressors making available a total of 15 lb. per sec. at up to 110 p.s.i. pressure. This air may be delivered directly to the test rigs at compressor delivery temperature, or any portion of it passed through an aftercooler.

Air for the Orenda atmospheric and altitude combustion test rigs is supplied by a blower which delivers 3.5 lb. per sec. of air at up to 3.0 p.s.i.g. This blower is driven by a 180 h.p. steam turbine and can be over-rated to deliver up to 5.5 lb. per sec. of air.

Water: The plant is provided with water delivered through a 30 in. water line from a pumphouse located on the shore of Georgian Bay (See Fig. 3). The pumping plant consists of four 2300 g.p.m. 231 ft. head centrifugal pumps each driven by a 200 h.p. induction motor, and a 1000 g.p.m. stand-by pump driven by a gasoline engine. Two of the main pumps are Crown Capital equipment assigned to Orenda Engines Limited, while the remaining equipment and building are owned by Canadian Industries Limited, who maintain and operate the pumphouse.

Fig. 3. Area Map Of Nobel.



Water up to a maximum of 6500 g.p.m. is normally available to the test establishment.

Two water storage tanks, each of 100,000 U.S. gal. capacity, are normally kept filled to cope with fire or other emergency. One is a gravity tank about 119 ft. high, which would supply water for fire-fighting purposes for a substantial period in the event of a power failure. The standby steam turbine-driven fire pump could, in this interval, be brought into service and draw on the further reserves in the 100,000 U.S. gal. stave tank. The gasoline motor-driven stand-by pump in the Georgian Bay pumphouse is, of course, the ultimate reserve.

Hydro: The main switchboard is located on the second floor level of the power house. One 44000/2200 v. 3-phase, 60 cycle transformer of 3000 K.v.a. capacity is located immediately outside the power house at this point.

The present hydro contract permits the use of two of the compressors between the hours of 7 a.m. and 7 p.m., and provides for adequate power between these hours for full operation of the Georgian Bay pumps and all other normal services and auxiliaries. The additional three compressors can be operated only between the hours of 7 p.m. and 7 a.m.

Fuel: The test fuel tank farm (See Fig. 4) has a total of nine storage tanks, four 30,000, one 10,000, one 5000 and three 1500 gal. size, giving a total capacity of 139,500 gal. The new afterburner rig uses JP 4 (wide range distillate), but all other combustion rigs normally use JP 1 (aviation kerosene) in the interests of safety.

Nobel Village

Built on land owned by Canadian Industries Limited, Nobel Village was founded in 1913 as a company town to house the supervisory personnel of their local explosives plant.

In 1940, to accommodate additional personnel of the war-time Defence Industries Plant, the village site was extended and additional houses and apartments erected. All but 66 of these units were removed to other government projects, such as Deep River, and of this number 44 (largely of the 2-bedroom type) are now occupied by Orenda personnel.

Description of Test Rigs

No. 1 Compressor Test Rig: The No. 1 compressor test rig was designed for the testing of multi-stage axial flow compressors in closed circuit operation. The closed circuit rig configuration, with provision for controlled evacuation of the circuit, simulates — for compressors currently on test — altitudes between roughly 70,000 ft. and 28,000 ft. The available drive horsepower defines the lower altitude limit.

In the closed circuit, the hot air leaving the compressor is turned downward in a vertical leg where it is throttled by a pintle valve which controls the compressor pressure ratio.

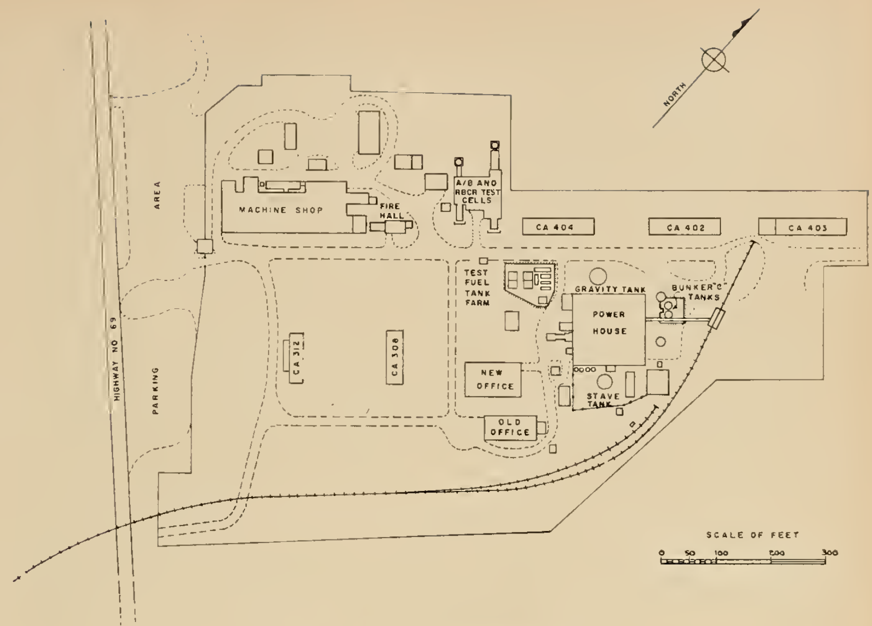


Fig. 4. Plan of Plant Area.

It is then turned horizontally and drawn through the air cooler. The airflow is measured in one of three interchangeable venturi meters, depending on the compressor under test, before turning upwards in a vertical leg and finally turning horizontal again where it passes through a long duct and screen section before re-entering the compressor.

The multi-stage condensing extraction type steam turbine can produce a maximum of 6500 h.p. at 3600 r.p.m. (its nominal rating is 4700 h.p.) with a steam consumption of 80,000 lb. per hr. The compressor r.p.m. is increased through the gearbox, normally by a ratio of 2.196 to 1, or optionally by rebuild of the gearbox, by a ratio of 2.976 to 1.

Air extraction from the circuit is from the highest pressure point of the rig — between the compressor and pintle valve — by a steam ejector which can reduce the air pressure in the rig to less than one p.s.i.a. at compressor inlet.

The air cooler operates with a coolant flow, normally 2500 g.p.m., of water pumped directly from Georgian Bay and discharged from the cooler to waste. The compressor inlet air temperature approaches the cooling water temperature under normal operating conditions; a minimum of 4°C is attained during winter. By reducing the water flow in the cooler, inlet compressor air temperatures of up to 100°C are obtainable.

Iroquois and Orenda compressors are tested on the rig to determine the characteristics of the configuration with new or modified blading.

On a normal test, some 75,000 separate readings are recorded and processed in determining the overall stage and rotating stall characteristics, surge line definition and strain gauge and vibration phenomena. This information is essential in the development of compressors to give higher mass flows for more thrust, improved or higher surge lines for better engine acceleration characteristics, and improved blade vibration characteristics for longer blade life.

No. 2 Compressor Test Rig: (Fig. 5) To investigate in detail the performance of a rotating blade row, it is simpler to investigate a single stage by itself rather than as one stage of a number on a multi-stage compressor test unit. The purpose, therefore, of a single stage unit is to allow the detailed examination of a single characteristic without the complication and interference of the multiple stages. No. 2 compressor test rig is used for single stage testing of advanced designs of compressor blading.

The rig consists basically of an inlet duct, compressor unit, outlet duct and exit throttle, drive turbine and condensor. The air is drawn through a filter house into an inlet venturi which measures the mass flow. The air then diffuses into a large diameter intake section and thence into the test unit proper.

In order to simulate actual compressor conditions, the test unit may have upstream of the blade stage under test—which comprises one rotor blade row and one stator blade row—several "tailoring" blade arrangements.

From the compressor unit the air is ducted to atmosphere via the corner turning vanes and a vertical leg of outlet ducting in which is situated a large electrically operated butterfly throttle valve for compressor pressure ratio control.

The compressor is fully instrumented with pressure and temperature instrumentation. Provision is made so that probes can be traversed simultaneously, both radially and circumferentially at entry and exit from each blade row. The probe traverse arrangement is such that mean values are obtained from three or four blade pitches for total head pressure, static pressure and yaw angle.

The drive turbine was a small reworked Chinook unit, which has been replaced with a two-stage Orenda II turbine capable of producing 2,600 h.p. at 8,500 r.p.m. The exhaust steam discharges into a jet condenser capable of handling 45,000 lb. per hr. of steam flow. The rig is capable of testing compressors which pass up to 150 lb. per sec. at pressure ratios of up to 1.3 to 1.

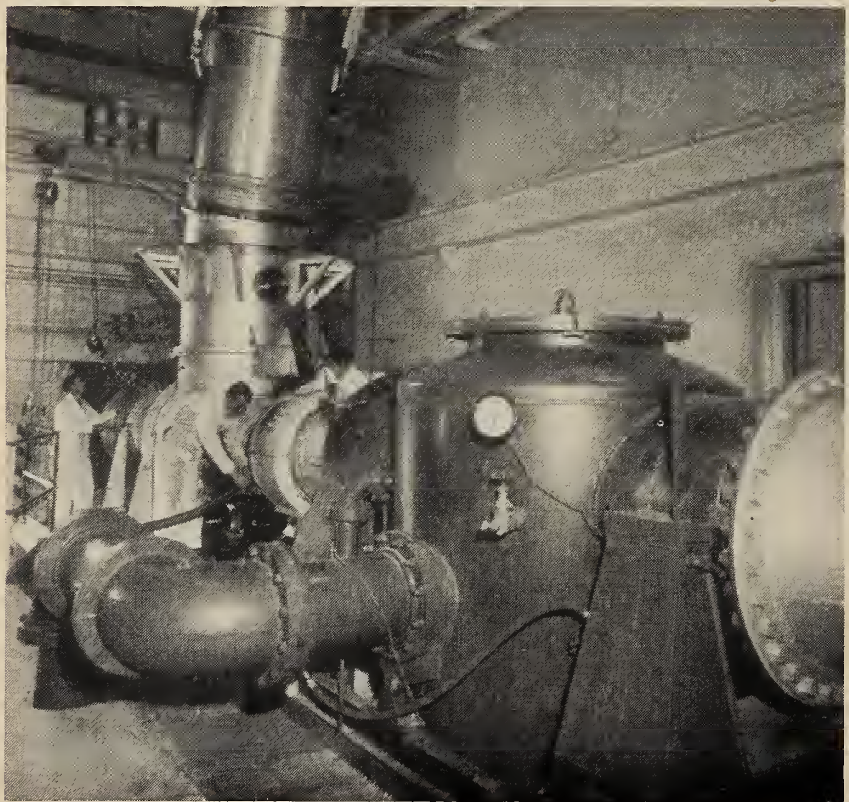
Cascade Test Rig: (Fig. 6 and 7) The cascade test rig, or variable incidence cascade wind tunnel, to use its full name, has been in use for nearly nine years, and has produced perhaps the largest quantity of useful results of any rig at Nobel. The rig has been in operation almost continuously and it has had only a few minor modifications since its initial installation. However, it has not reached the end of its usefulness, as there is still much to be covered in determining blade characteristics. It is through these tests that our basic knowledge of gas turbine blading for use in compressor and turbine design is obtained.

A cascade is made up of a number of constant section blades representing only one of many combinations of pitch/chord ratio, thickness/chord ratio, stagger angle and camber angle. In addition to these variables, there are also changes in basic profile, non-standard blade forms and special blades to be tested. A cascade is usually tested at various incidences and over a range of inlet Mach numbers to determine the positive and negative incidence stall point and the highest loss limiting Mach number at each incidence. The total pressure loss, static pressure rise, air deflection and deviation angles are found and in this way the working range of a blade is established, as well as its optimum operating conditions. Over 500 different cascade configurations of compressor turbine and inlet guide vane blades have been tested to date.

The rig is supplied with up to 15 lb. per sec. of air from the compressors through a 10 in. diameter pipe. From this pipe the air passes through a converging duct which changes the cross-section to a smaller rectangular shape (area ratio 1.7 to 1.0). The air then enters a tunnel which has parallel top and bottom plates but where a further reduction in area (approximately 1.8 to 1.0) is achieved due to the profile of the sliding side walls; this area depends upon the angle to which the tunnel is set. The cascade can be rotated to give air inlet angles from zero degrees to 67° as required to cover the cascade incidence angle range. The air then passes through the cascade of blades and out to atmospheric pressure in the test cell and is directed through the cell wall by outlet guide vanes. Injection of high pressure air into the boundary layer — parallel to the gas stream — straightens out the gas stream at the inlet to the cascade.

Pitot and yaw traversing is conducted downstream of three blades of the cascade. An automatic recorder system in conjunction with a photocell manometer and a yaw capsule amplifier system gives a permanent record of each test as well as carrying out an integration and averaging of flow conditions downstream of the cascade.

Fig. 5. No. 2 Compressor Test Rig.



Probe Rig: (Fig. 8) The calibration and evaluation of various aerodynamic and thermodynamic probes under known and controlled conditions in the probe rig is required in order to properly evaluate the results obtained when these probes are later used in engine and aerodynamic test units. In addition, this rig plays a major role in the research and development of probes.

The general aim in aerodynamic work is to obtain the necessary accurate data from the test unit with the least interference from the sensing devices. Hence, a demand always exists for smaller and stronger probes which will sense total pressure, static pressure, yaw and total temperature either in the form of a single or combined probe. Other factors which affect both probe design and performance are wall effect, Reynolds number, pressure gradients, turbulence and response. As the operating velocities of the various test units and engines increase, so the effect of compressibility and shock waves will become more prominent and require different probes and techniques.

The probe rig consists of a 17 in. diameter total head tank which is supplied with air from the compressors through a 10 in. diameter pipe, a diffuser and screens. Situated on the end of the total head tank is an aluminum 4.5 in. diameter quarter elliptical nozzle. The probe is held in the nozzle jet by a traverse micrometer with remote yaw control. The micrometer is mounted on a tilting bridge, which can be moved along the axis of the nozzle jet, spanning the nozzle stream.

The true total head pressure and temperature are obtained in the total head tank where the air velocities are very low and the values can be sensed accurately. These readings are compared with those obtained from the probe under calibration at various Mach numbers, over the operating range of the probe. The static pressure of the nozzle jet is assumed to be ambient and the static pressure of the probe is compared with the barometer at the time of test. The probe is normally evaluated under various conditions of tilt and yaw to obtain a general idea of its performance under non-axial flow conditions. The general operating range of the Probe Rig is from 0.1 to 0.65 Mach number which can be obtained from the air flow available during the day.

It is possible to choke the nozzle with the full output from the compressors but the nozzle is not generally suited to transonic and supersonic work. The limiting Mach number is approximately 0.80.

The probe rig is also used to provide air for other miscellaneous airflow rigs.

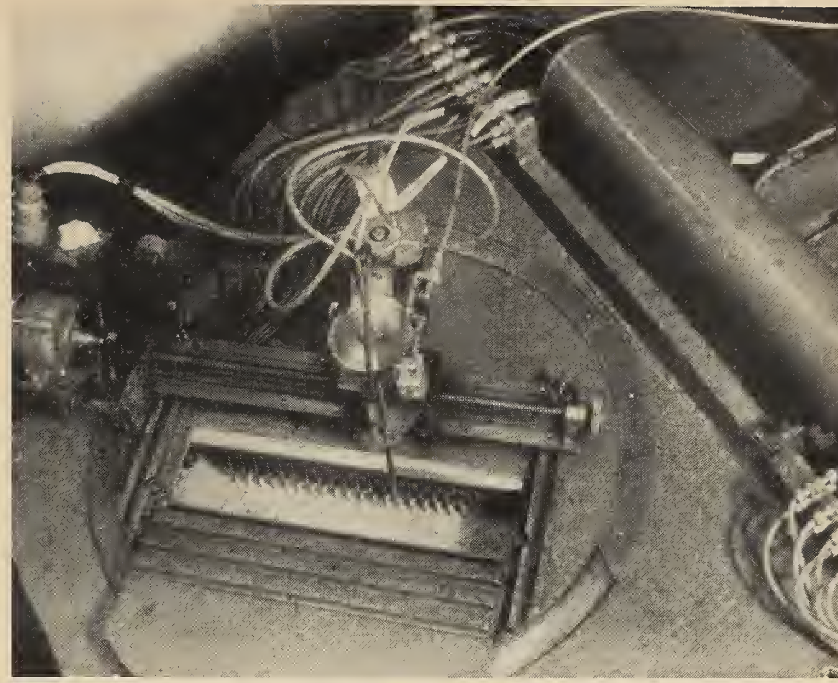


Fig. 6. Cascade Test Rig.

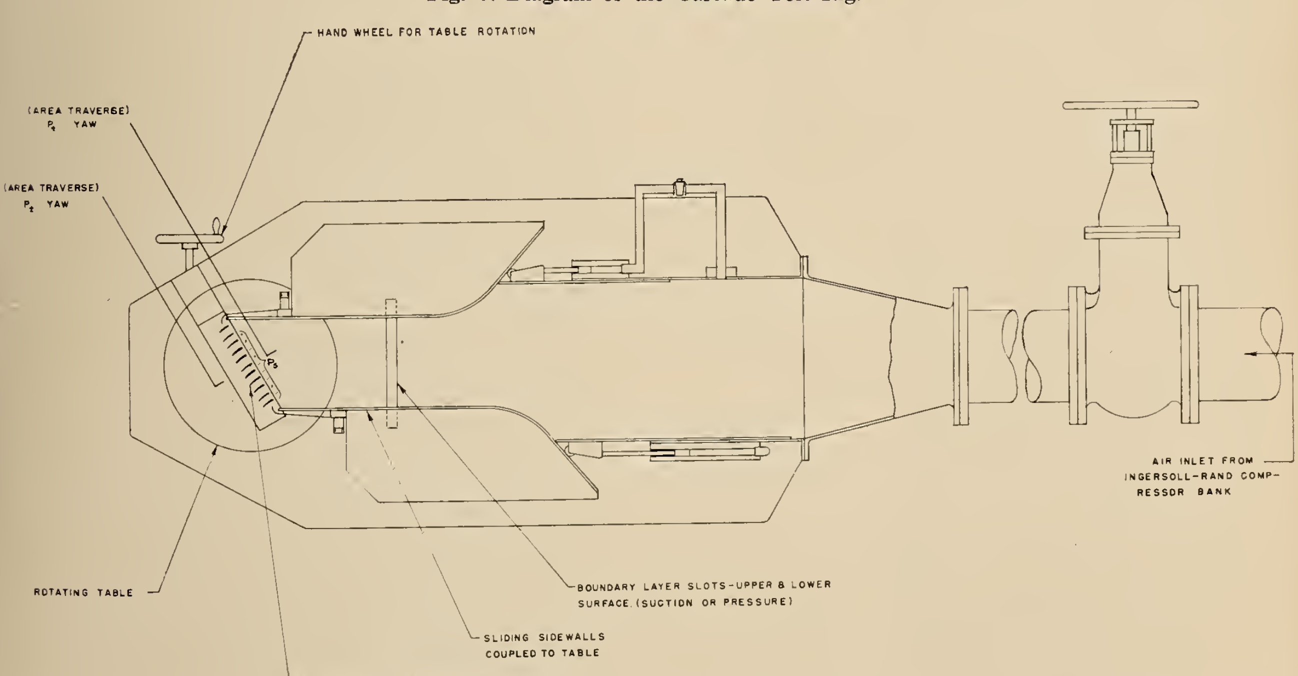
Cooling Air Ejector Test Rig: (Fig. 9 and 10) After-burning in the modern jet engine for high speed flight has developed to the stage where it is imperative to cool the external surface of the jet engine and the afterburner fuel supply as a protection against the heat generated during after burner fuel operation.

This is done by ducting air from the engine air intake around the engine in two passages. The inner or secondary cooling air is ducted concentrically around the jet pipe, while the tertiary air ventilates the fuel manifold and turb-pump area to prevent contact of combustible vapours with hot engine parts. An adequate flow of air is maintained at all times by a double ejector in which the jet efflux from the engine final nozzle is used as the driving medium. The secondary and tertiary ejector nozzles are concentric with the engine final nozzle.

It has been found that the thrust of the primary nozzle can be increased or decreased by the addition of ejectors and that careful ejector nozzle design is necessary if full advantage is to be taken of its effects. The cooling air ejector test rig was designed to investigate the performance of small scale models of the ejector assembly.

The rig is entirely supported by flexible straps attached to the ceiling and is isolated from the inlet duct by an air breathing or seal which facilitates the measurement of the thrust of the ejector configuration. The main air supply is ducted through the air bearing arrangement into a plenum chamber whence it is ducted to the three nozzles of the ejector

Fig. 7. Diagram of the Cascade Test Rig.



through flow tubes, venturis, and valves to the annular ducts in the header assembly, on to which the test nozzle specimens are attached. To enable constant flow ratios to be maintained between the cooling and primary airflow, the secondary and tertiary flow tubes are connected to a common source in which is situated a choked orifice.

The general characteristic of the ejector is obtained over a range of primary, secondary and tertiary pressure ratio during which the following measurements are taken: primary, secondary and tertiary total pressure; primary, secondary and tertiary mass flow, and overall thrust of the ejector configuration.

The maximum pressure ratio across the primary nozzle is limited by the air supply of 15 lb. per sec. from the compressors. This has to serve the primary, secondary and tertiary flow paths but of these the largest proportion passes through the primary nozzle and limits the pressure across it to slightly less than 7.0 to 1.

In addition to air ejector testing, this rig has been adaptable to jet deflection tests and to other work such as evaluation of the exhaust ejector for the engine altitude test facilities.

Slip Ring Test Rig: For engine development work, a slip ring is necessary to convey strain gauge, thermocouple, or any other low level signal, from the engine rotor assembly to the engine frame and thence to instruments for analysis. The development of a suitable slip ring unit for the modern engine poses a particularly difficult problem since, due to space limitations, the contact brushes must operate at rubbing speeds of the order of 500 ft. per sec. Since signals of less than 100 microvolts are often invesitgated, considerable refinement of design is required to ensure that the required signal is not masked by surface contact interference.

The slip ring test rig was designed to reproduce the operating environment of the slip ring unit on an engine. It encloses the unit in a case which can be flushed with air at up to 200° C at various pressures. Drive is from a 15 h.p. electric motor through a variable speed transmission which permits operating speeds from 1500 to 9000 r.p.m.

In addition to evaluating various basic designs for slip ring units, this rig can be used for comparing and analysing such variables as ring material, ring surface finish, brush material, and brush design.

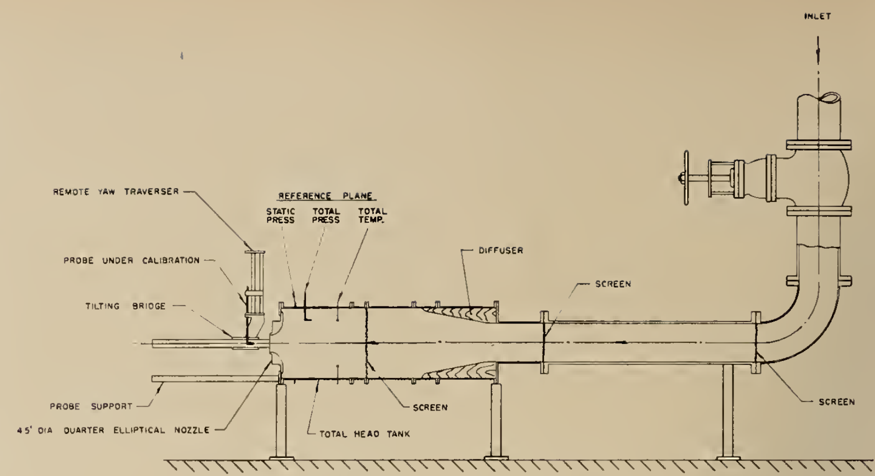


Fig. 8. Diagram of the Probe Test Rig.

Static Blade Cooling Rig: To improve the performance and output of a gas turbine engine it is desirable to increase the combustion temperature and hence the temperature at the turbine inlet. If higher temperatures are to be tolerated, either improved turbine blade materials or cooled turbine blades are required. The static blade cooling rig was designed to carry out preliminary testing on various cooling blade configurations. The more promising blade configurations are then tried in the rotating blade cooling rig. The test blades have cooling passages of three basic types, chordwise, radial or helical. The type of construction of the blade is either load carrying shell, load carrying strut, hollow shell without baffles, or integral construction. Blades made up of different combinations of the above are tested in the static blade cooling rig.

The airflow to the rig is supplied by two compressors giving six lb. per sec. This airflow is augmented by an air injector which draws an additional 1.5 lb. per sec. The air is brought to the rig through a 10 inch diameter pipe. Then it goes to the air injector after which it passes on to a preheater, basically an Orenda combustion chamber, and thence to a mixing chamber where the combustion gas flow is evened out. From the chamber it goes through a transformation duct conducting the flow from a circular passage to a rectangular passage. Here it enters the hot cascade box in which are mounted one centrally located cooled blade specimen with two dummy blades on either side, making a cascade of five blades. After passing from the hot cascade box, the gases are spray cooled with water and exhausted to atmosphere through a stack.

Blade cooling air and root cooling air are tapped off the air supply line upstream of the air injector. The root cooling air flow is fixed and does not change throughout the test. It is heated by two heaters, then fed into the hot cascade box from the bottom. Here it enters the root cooling air chamber in the bottom of the liner where it cools the root of the blade and exhausts into the main gas stream. Both the blade cooling air and the root cooling air can be controlled for mass flow and temperature. The cooling flow is usually varied from 1% to 4% of the total flow past each blade. Thermocouples are located at the root, mid-section and tip of the blade. The testing is carried out then to determine the effective cooling, the blade temperature distribution and the pressure loss in the blade passages at various flow and temperature conditions.

Rotating Blade Cooling Rig: The rotating blade cooling rig is essentially a turbine test rig but is specifically designed to develop various types of cooled turbine blades both as to mechanical reliability and performance. Evaluated on this rig are the more promising blade designs as determined by testing on the static blade cooling rig.

Preheated air is supplied by an upstream slave unit consisting of a rig compressor which pumps air through a rig combustion system and modified combustor in series. The air so delivered to the turbine simulates a high altitude flight condition. After expanding through the turbine the gases are cooled with a water spray and passed through an outlet silencer.

The rig is driven by the test turbine, but to allow for mismatching of this turbine with the rig compressor excess power is absorbed by an eddy current dynamometer (formerly used on the turbine test rig in the power house) which is capable of absorbing 6000 h.p. at speeds between 5000 and 9000 r.p.m. The rig is protected by special speed trips.

Blade cooling and root cooling air is drawn from the ducting downstream of the rig compressor and raised to the required delivery temperature in the combustion preheater. It is then reintroduced to the rig through radial tubes in the duct upstream of the modified combustor, and thence fed through an axial passage to the blade cooling and root cooling system.

The turbine test unit is heavily instrumented for the recording of blade temperature and vibration stresses by thermocouples and strain gauges which produce signals which are transmitted through a water-cooled slip ring unit in the tailcone to the recording instruments.

The turbine test unit is designed to duplicate closely the design of the rotating components so that gas loads, speed, and vibratory forces are the same as on an engine. Provision is made for visual examination of the test blades and for removal and replacement of the first row of blades.

Afterburner Rig: (Fig. 11) This rig, completed during the first week of September, 1956, is intended for use in evaluating the burning characteristics, stability range and mechanical properties of various full scale afterburner systems.

The rig consists basically of a slave engine with reheat exhausting into an injector. The augmented gas flow passes through a mixing duct, then through an annular measuring duct into a test rear frame and jet pipe in which afterburner test specimens are mounted. The exhaust gases are cooled in the exhaust duct and pass through a silencer to atmosphere.

By means of adjusting the slave engine reheat fuel flow and engine speed it is possible to vary the primary and augmented gas flow. Thus, it is possible to vary the test unit inlet Mach number and gas temperature.

The pumping capacity of the present rig configuration is 160 lb. per sec. of gas flow up to 750° C at 5 psig.

Sector Afterburner Rig: The sector afterburner rig is intended for use in evaluating the stability range and burning characteristics of segments of various afterburner systems.

Air from five compressors is preheated in a rig combustion chamber and passes through a mixing duct into the sector afterburner where the test specimens are mounted. Exhaust gases are water cooled and passed through a silencer to atmosphere.

A sector unit of this type cannot duplicate various types of screech instability sometimes found on annular afterburners, but to minimize temperature gradients and other end wall effects, the radial walls of the sector are ceramic which is allowed to heat up to the full gas stream temperature. The test unit is fitted with observation windows.

The upstream airflow is adjusted by means of an air operated valve, and the afterburner inlet temperature is varied by altering the preheater fuel flow. The maximum air flow obtainable is 15 lb. per sec.

Sector Altitude Combustion Rig: The sector altitude combustion rig is used for combustion development work on altitude ignition, stability limits and performance.

Air is drawn from atmosphere through one of three interchangeable flat plate orifices, is throttled by a remote-operated butterfly valve, is smoothed by two screens, and passes through a transition duct into the combustor inlet. The combustion unit is ceramic lined on the radial walls to minimize end wall effects and has viewing windows for observation of the combustion process. Downstream of the combustor a 60 degree sweep traverser is used to obtain gas samples and temperature and pressure profiles. The gases are then ducted to the steam ejector which exhausts through a silencer to atmosphere.

The ejector consumes 100,000 lb. per hr. of steam at 205 psi and provides, for a typical combustion unit, cold air inlet conditions between 4.6 in. of mercury absolute at a mass flow of 3.0 lb. per sec. and 24.0 in. of mercury absolute at a mass flow of 18 lb. per sec.

It is planned in the future to use this test rig for altitude afterburner work and to install a preheater so that realistic operating conditions can be set up for performance tests.

Orenda Altitude Combustion Rig:

Fig. 9. Cooling Air Ejector Test Rig.

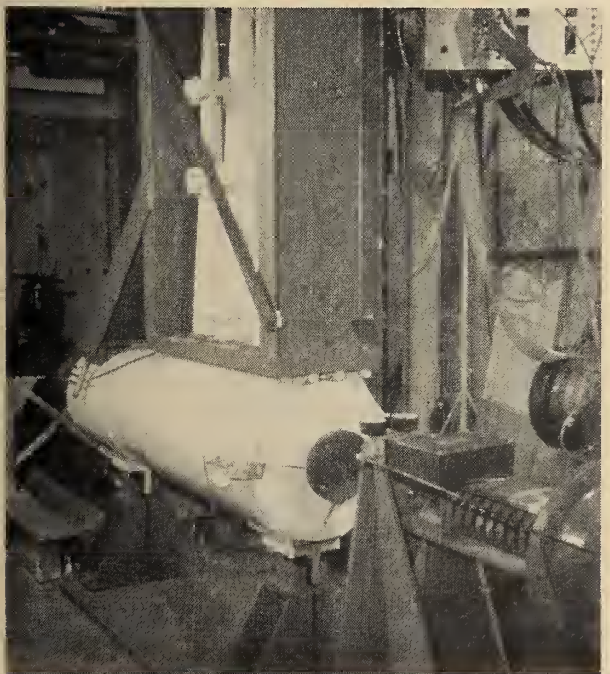
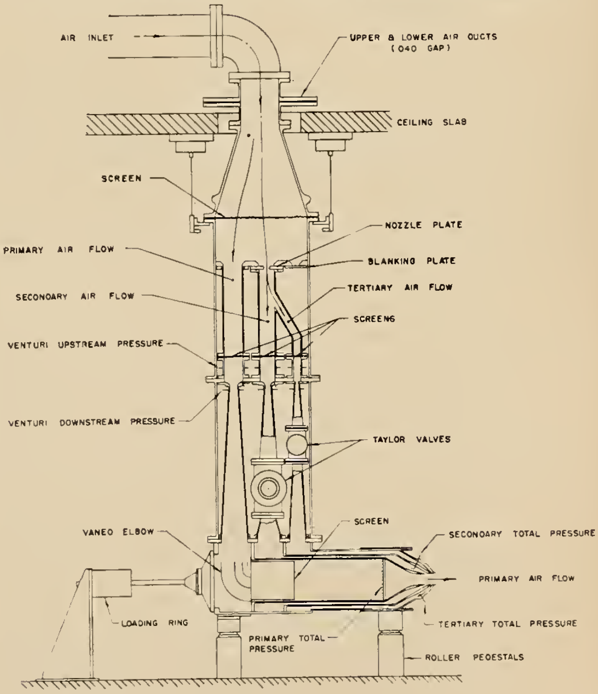


Fig. 10. Diagram of the Cooling Air Ejector Test Rig.



The Orenda altitude combustion rig is used for determining ignition and stability characteristics of various combustion chamber configurations under altitude conditions.

Air is drawn from the cell through one of a series of inter-changeable orifice plates, or alternatively for higher mass flows, through an electric preheater which may or may not be used, and a low-loss venturi meter. The air from either source is throttled by a remote operated butterfly valve and flows to a total head tank from which the two dimensional primary zone box is supplied. This box is fitted with viewing windows.

The combustion gases are drawn from the test unit by an ejector which uses 30,000 lb. per hr. of steam at 125 psi. The characteristic curve of this ejector permits testing at a lower pressure in the test specimen than is attainable on the sector altitude combustion rig.

Orenda Atmospheric Combustion Rig: This test rig was originally designed to test Orenda combustion chambers of various configurations at roughly sea level atmospheric pressure, which simulates altitude operation of the combustor in a complete engine. The rig is now inactive for Orenda work, and is used for airflow studies, and with the addition of a combustion preheater and a special downstream duct, for thermocouple response tests.

The air supply for the rig is obtained from a blower which is rated to deliver 3.5 lb. per sec. of air at 3.0 psig. A 450 Kw electrical air preheater equipped with a temperature controller is installed in the air line downstream of the blower. An alternative air supply may be drawn from the compressors by means of a four inch diameter crossover line entering the rig supply line downstream of the preheater. The preheater must be isolated when this supply is used. Air flow to the rig is measured by a venturi meter.

Orenda High Pressure Combustion Rig: This test rig has been used for the testing of Orenda type combustion chambers under conditions approaching sea level flight. The 15 lb. per sec. of air available from the compressors duplicates the mass flow in one Orenda type chamber under low altitude conditions, but permits set-up of correct air velocities and air fuel ratios for sea level investigations.

Outlet temperature distribution, metal temperature, pressure loss, and combustion efficiency determinations and "slam throttle" deceleration simulations typify the work done on this rig.

Air from the compressors passes through an Orenda type combustion preheater to a total head tank and thence to the test combustor. A water-jacketed traversing section downstream of the combustor is used for determining temperature and pressure profile. The outlet gases are cooled with a water spray upstream of a remote operated butterfly valve which establishes the combustor outlet pressure.

Turbo Pump Rig: The turbo pump rig is used to evaluate and calibrate air turbine driven fuel pumps of various designs.

Air is supplied to the turbine after passing through a metering orifice, steam and electric preheaters (for low flows), and a combustion preheater (for high flows). Air from the turbine may be exhausted to atmosphere, or drawn through piping to the Foster-Wheeler steam ejector for altitude work. Air requirements at turbine inlet may vary from four pounds per second at 100 psia. and 300° C, to one pound per second at seven psia. On a typical test, measurements are made of the turbine air flows and pressures required to give desired fuel flows and pressures. Speed indication is by an inductive pick-up which imposes no restraint on shaft rotation.

A closed circuit fuel system provides up to 65,000 lb. per hr. of fuel at the test pump inlet at 15 psig. pressure after passing from the boost pumps through a filter, a cooler and a flowrator. Fuel discharge is throttled and then returned to the supply tank. The discharge system is designed to withstand up to 1500 psig.

Waterflow Analogue Rig: The rig is used for visualization of flow patterns in main combustion chambers and in afterburners to determine, for example, reasons for flame tube hot spots, and optimum position for igniter plugs.

The test section of the rig is a plate glass tank which will hold a model, generally constructed of plexiglass, up to 15 x 15 x 48 in. The rig is in the form of a closed circuit, using water as the flow medium with a pump which will deliver 2000 gpm, although for normal running much less than this is used.

The analogy follows the Reynolds' principle that different fluids can be made to have similar flow patterns if the Reynolds' number is made the same. It has been found by other waterflow rig operators that combustor flow pattern is sensibly independent of Reynolds' number so long as the flow is in the turbulent regime. This allows the rig to be run at velocities of the order of 10 ft. per sec. which are low enough for convenient viewing and also low enough that the model is not overstressed.

In operation, air bubbles entrained in the circulating water reflect the light from a special slit-beam light source which can be adjusted to give the flow pattern in any desired plane. These patterns may be examined visually, photographed using flashbulb slit illumination, or filmed with a motion picture camera.

Acknowledgements

The author wishes to thank Orenda Engines Limited for the opportunity to present this paper and the engineers of the Nobel Test Establishment for the use of their descriptive literature.

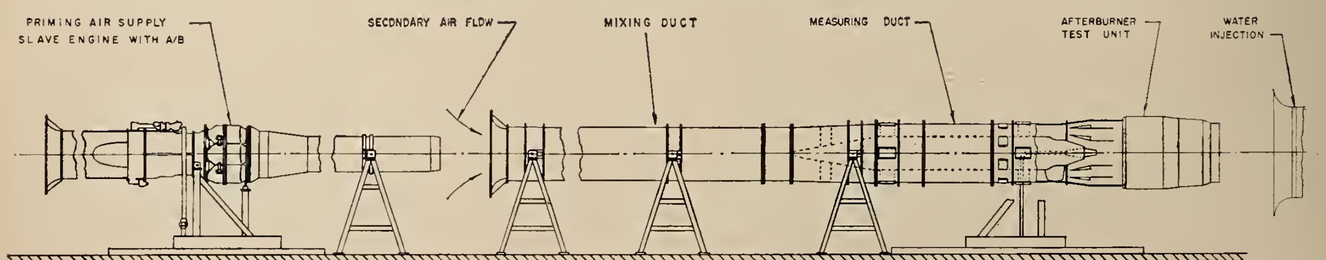


Fig. 11. Diagram of the Afterburner Rig.

ENGINEERING STUDIES OF THE FRASER RIVER BASIN

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Adequate control of the Fraser River against a "design flood" greater in magnitude and volume than any known discharge could be realized through a system of power and storage dams located throughout the main river and its tributaries. Such a system would not only keep the freshet flows in the Lower Fraser Valley within the capacity of the existing dyke system, but would also be economically self supporting through the sale of electrical energy. However, the three suggested systems each with over 5 million k.w. of firm power do not include fish facilities, which were omitted primarily because of lack of pertinent information on all factors involved.

This led the Fraser River Board to a study of partial developments of the three main systems which, while having a minimum adverse effect on the fishery resource, would be part of an overall system in which flood control would still be realized, while the total cost would still be borne by the sale of electrical energy. The preliminary investigations carried out in support of these conclusions revealed a lack of representative meteorological data, which has been partially corrected through the introduction of a snow survey program. Similar lack of hydrometric data or only short term records necessitated correlations with older stations to obtain 20 yr. of continuous discharges.

General Scope

WHILE the title of this paper is rather broad in its implications, the intention is to describe the water resources of the Fraser River Basin, the tentative planning for its use and some of the problems encountered in carrying out the preliminary investigations.

Much of the material that follows, including the illustrations, has been taken from the *Preliminary Report on Flood Control and Hydro-electric Power in the Fraser River Basin* which was completed by the Fraser River Board in 1958. The paper is limited, therefore, to the early stages of water resource investigation in a relatively undeveloped river.

Comparative Size

In recent months much publicity has been given in the press, not only to the Fraser, but also to the Columbia and Peace River systems. All three have their headwaters in British Columbia and it is interesting to note that, because of their geographic positions, each watershed presents certain unique characteristics or conditions. Thus the Columbia is an international stream, the Peace an interprovincial stream, while the Fraser might be termed the "Ole Man River" of British Columbia for, with the exception of one small southern tributary, its watershed is wholly contained within the Province.

In terms of average annual runoff the Fraser at Vancouver with 80 million acre feet* exceeds the Columbia at the international border and is over three times the Peace discharge as measured at Hudson Hope.

Internationally the average annual discharge of the Fraser at Hope of nearly 68 million acre feet* is about equal to that of the Nile River at the famous Aswan damsite.

Salient Features

Physical Features: A great trough from one to three miles wide, known as the Rocky Mountain Trench, extends northwesterly through the eastern portion of the Province separating the Columbia Mountains to the west from the Rocky Mountains to the east. Within this trench, proceeding from the international border northwesterly, can be found the headwaters of the Columbia, Fraser, Peace and Liard Rivers.

The Fraser itself originates near Beacon Peak about 30 miles south west of Jasper and in its first 70 miles drops some 4,000 ft. meeting the Rocky Mountain Trench at Tete Jaune at an elevation of 2,400. For the next 250 miles it pursues a meandering course within the trench, emerging from it and turning southward near Prince George. This portion of the river is a rather sluggish stream with average gradients between 1/5000 to 1/10,000.

In its course southward through the rising Interior Plateau country the river valley deepens from a few hundred feet at Prince George to about 5,000 ft. near Lytton. In the next 70 miles the Fraser River cuts through the Coast Range Mountains, emerges at Hope and turns westward to flow through the alluvial valley of the Lower Mainland. It finally discharges at Vancouver into the Pacific Ocean.

From its source to its mouth the total length of the river is 850 miles. Its drainage basin comprises some 84,600 sq. miles or almost one quarter of the total area of the Province. This does not include the Aluminum Company of Canada's Upper Nechako Watershed of 5,400 sq. miles since most of its inflow is now diverted westward through the Coast Range to the Kemano power house.

Other main tributaries of the Fraser from the west include the lower Nechako, Chilcotin, Bridge and

* Annual discharge does not include 4.5 million acre feet of Upper Nechako River Basin inflow, a large portion of which is now diverted westward through the Aluminum Company of Canada plant at Kemano.

Lillooet Rivers. While the Upper Fraser dominates the drainage from the eastern mountains, its inflow is also augmented by the Quesnel and Thompson Rivers.

Climate: It is not surprising that such an extensive watershed contains no fewer than 5 distinct climatic regions* varying from alpine sub-arctic in the north to alpine maritime in the south. The precipitation and the temperatures which occur in these various regions are the most pertinent factors to be considered in a study of hydrology of the watershed, and climatic considerations will be limited to these two items.

Precipitation: The moist air of the Pacific Ocean in passing eastward over the Coast Range Mountains into the Fraser River watershed is subject to varying temperature and pressure conditions. The greatest precipitation occurs in the south west portion of the basin, where small drainage areas adjacent to the Lower Fraser Valley may receive over 100 in. per year. Further north much of the moisture falls on the west side of the Coast Mountains but nevertheless the head-waters of the Nechako, Chilcotin and Bridge receive precipitation averaging over 60 in. per year.

At the same time the Coast Mountains do create an effective rain shadow over the Interior Plateau, and in this central region around Ashcroft and Kamloops an extremely low precipitation of only 7 to 9 in. is experienced.

In contrast, the precipitation to the east rises from 40 to 60 in. along the Easterly Mountain slopes. It is from this region, which includes the Upper Fraser and Thompson River systems, that a major portion of the runoff occurs.

It is of great significance that about two thirds of the precipitation occurs as snow which accumulates at the higher elevations during the winter months.

Temperature: Spring temperatures particularly in the main snowfields located at elevations of 4,000 to 7,000 ft. play a very predominant role in the hydrology of the basin. Generally during the winter months temperatures well below freezing are experienced throughout the interior watershed.

Under normal conditions the spring thaw begins in the south and moves northward and upward into the main snow regions. However, the change from winter to summer can be very rapid as was noted in the record

* Climatic areas listed in descending order of magnitude are Dry Continental, Humid Continental, Alpine Humid Continental, Alpine Maritime, and Alpine Subarctic.

Fig. 1. Potential sites included in System 3.

flood year of 1948 when warm moist air from the Pacific Ocean invaded and occupied the snow fields for many days, thus producing a high and sustained period of melting.

Hydrology

The hydrology of the Fraser River watershed is typical of a predominantly snow-fed basin which experiences one main flood each year. In early spring the valley snow (generally below the 3,000 ft. elevation) melts and runs off. This may cause minor local flooding, but the discharge at Hope does not show any appreciable increase until above freezing temperatures occur at the 5,000 ft. elevation. In fact, continuous warm weather during the latter part of May and the first few weeks of June can produce a rapid rise of about 1 ft. a day on the Mission gauge some 60 miles downstream from Hope.

It has been found that 85% of the annual runoff occurs in the seven month period of March through to September, and on many of the tributary watersheds melting snow supplies this discharge entirely.

Historic Floods: Although accurate hydrometric information on the Fraser at Hope only goes back to 1912, it has been established from old water level records that the 1894 freshet was the greatest known flood. In those early days the Lower Fraser Valley was very thinly populated and damage was not too extensive. However, as more and more people occupied the flood plain of the river they were forced to protect themselves from the high water by the construction of dykes. At first these improvements were by individual effort only, but eventually private dykes were joined up and incorporated into districts. Today there are 31 dyking districts along the river between Agassiz and Vancouver in which a total of 223 miles of dykes protect some 160,000 acres from the river and in some instances the sea.

Flood of 1948: In some respects the spring of 1948 was similar to the record high water year of 1894. Barkerville in the north central portion of the watershed at elevation 4,180 (about 400 ft. above the mean watershed elevation) was experiencing mean daily temperatures about 5° above freezing during the first week of May. By the 10th of the month the temperature had started to rise and by the 29th reached a peak of 65° F. and remained very near this maximum for about 3 weeks. This rapid invasion of the snowfield by warm air produced a steadily increasing runoff which funnelled past Hope causing a rise of about one foot a day on the Mission gauge.

In most years during this critical period there are lapses in the temperature, which reduces the snow melt rate. This in turn is reflected through falling discharges at Hope several days later. However, the 1948 flood was the exception to the usual condition for it never cooled off.

The maximum daily temperature of 65° at Barkerville was followed two days later by a peak discharge of 536,000 c.f.s. at Hope. However, for the next 10 days the water levels on the downstream Mission gauge remained almost constant and in fact rose to a maximum height of 24.73 ft. on June 10, 1948.

Other regions along the Fraser and its tributaries including Kamploops, Prince George, and Quesnel had also suffered and in fact throughout the Province the rivers had gone on the rampage. Nevertheless by far the greatest damage had been wrought in the lower Fraser Valley where 55,000 acres, or almost ⅓ of the dyked area, had been flooded. In fact, out of a total of some $20 million expended by the Federal and Provincial Governments throughout the Province, $17.5 million was used in the lower Fraser Valley with about one half of this amount going to dyke reconstruction.

The latter work was carried out by the Fraser Valley Dyking Board, made up of Federal and Provincial agencies. Their all-out effort in reconstructing over 200 miles of dykes by early 1950 was a tremendous undertaking and it was fortunate indeed that this work was completed in time to withstand the 1950 spring freshet which rose within half a foot of the record 1948 level at Mission.

Multipurpose Investigations

While the immediate remedy of limited dyke protection was going ahead the two governments were beginning to realize the need for a comprehensive water resource plan of the whole watershed.

By the end of 1948 the Dominion-Provincial Board, Fraser River Basin had been formed with representation from nine government agencies. Its terms of reference were broad, but essentially it was charged with preparing a plan of multiple purpose development of the whole watershed with emphasis on flood control. In its early days the Board concentrated on collecting basic data and mapping many miles of river valley.

New terms of reference in April 1955 reduced the Board to a membership of six and changed its name to the Fraser River Board. The new Board picked up the work of its predecessor and a year later produced an interim report on flood control.

In March 1956 its membership was further reduced to four, but through working groups and additional Board staff its efforts were intensified and a second publication entitled *Preliminary Report on Flood Control and Hydro-electric Power in the Fraser River Basin* was presented to the two Governments. Much of the information already quoted and some of that which follows has been taken from this report.

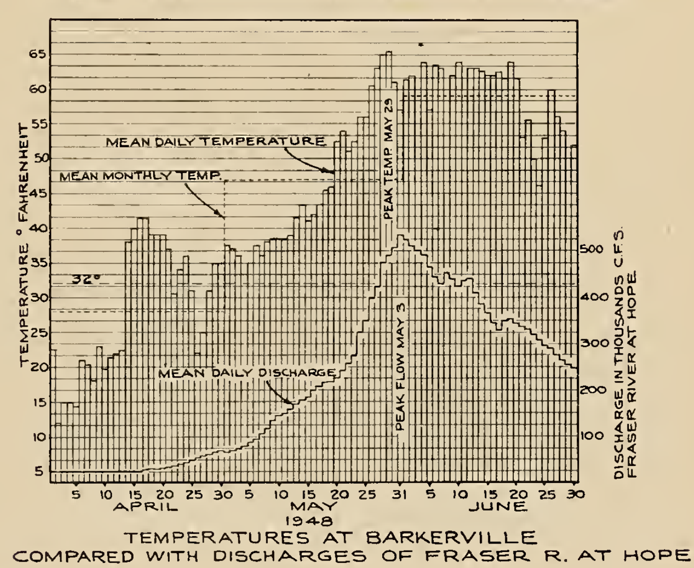
Flood Control: Early attention was given by the Board to the determination of the design flood and the best method of protecting the lower mainland from discharges of this nature.

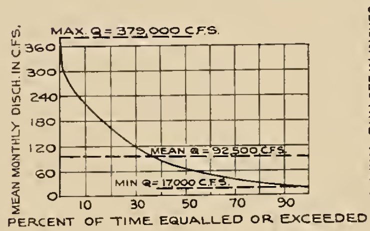
The basis for this study was the hydrometric records at Hope, available from 1912, and downstream river levels at Mission which are partially effected by tides. Finally, with the design flood hydrograph determined, upstream discharges were computed to show the expected contribution from each portion of the watershed.

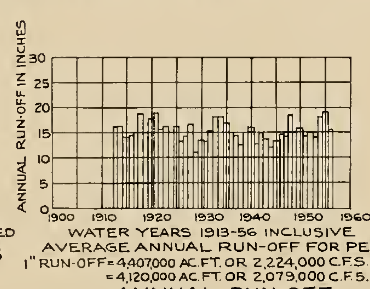
Prior to arriving at the design flood a simplified plot was made of the annual spring hydrographs at Hope for discharges above 250,000 c.f.s. This base flow, equivalent to about 19 ft. at Mission, was chosen because it is approximately bankful capacity and it is at this discharge that the dykes start to take effect.

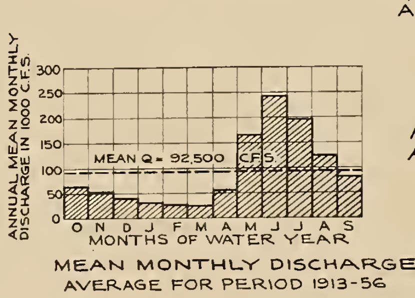
In examining the various hydrographs, the 1948 curve, with its peak discharge of 536,000 c.f.s. and its total volume above the base flow of 5.4 million c.f.s.-days (for May, June and July) was found to be the greatest recorded flood both in magnitude and volume. However, from old historic high water marks it was evident that 1894 crest had exceeded

Fig. 2. Barkerville Temperatures and Hope Discharges









From Fraser River Board Preliminary Report 1958.

this record and probably reached a maximum discharge of 600,000 c.f.s. although little was known about its volume.

Essentially, then, in arriving at the design flood hydrograph an enveloping curve simplified to the form of a triangle was constructed in which the altitude was made equal to 600,000 c.f.s. The rising stage was made somewhat steeper than the 1948 hydrograph and, while the falling stage did not enclose the less critical and long drawn out 1920 and 1933 flood hydrographs, it presents a somewhat flatter gradient than either the record 1948 or 1950 freshets.

The Alcan diversion of some 5,400 sq. miles of the Upper Nechako watershed runoff resulted in the reduction of 24,000 c.f.s. in the peak discharge, so that the final design flood hydrograph parallels the higher curve reaching a maximum discharge of 576,000 c.f.s. The volume contained within this modified design flood hydrograph is 7.86 million c.f.s.-days above 250,000 c.f.s. extending over a base period of 48 days.

Part of this flood could, of course, be contained within the existing dyking system, and a maximum safe discharge curve which reached a peak of 375,000 c.f.s. equivalent to 23 ft. at Mission was superimposed on the flood hydrograph. The problem, then, was to control some 5.22 million c.f.s.-days of surplus water, the difference between the design flood hydrograph and the discharge the dykes could safely contain.

The Fraser River Board investigated a number of flood control methods and reported that an improved dyking system in combination with upstream flood retention reservoirs looked like a promising solution. Under this system, storage reservoirs located throughout the watershed would be drawn down during the fall and winter months in readiness for the spring flood. The river would then be so regulated that it did not exceed the maximum safe discharge capacity of the lower river channel.

Flood Control and Hydro-electric Power: It was immediately evident that flood control through improved dykes and upstream flood retention reservoirs would be an expensive undertaking, roughly estimated in the neighborhood of $150 million. However, the obvious answer in part was to use the stored water for the production of electrical energy.

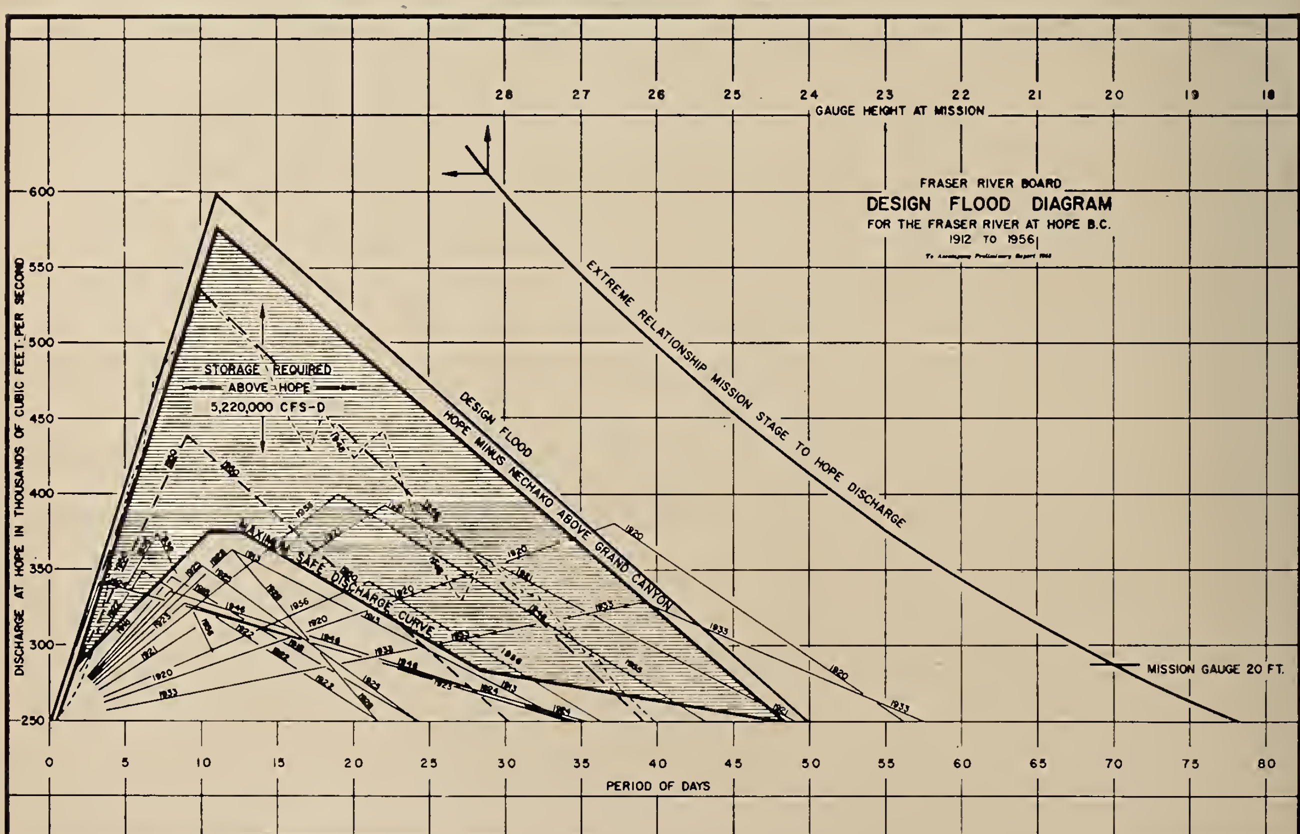
Thus flood control and hydro-electric power were the basis of the Board's preliminary report completed in 1958. It offers a choice between systems any one of which would, in combination with flood control, provide 5 million k.w. of firm capacity, or about double the existing Provincial hydro-electric facilities. On the basis of the value of the electrical energy alone and not including flood control benefits such a system would pay for itself. Very roughly the cost of any of the three systems would amount to $2 billion from which an annual wholesale return of $300 million might be realized from the sale of electrical energy.

Effects on Fisheries: However, the preliminary report points out that such a system of storage and power dams on the main Fraser and such tributaries as the Thompson and Quesnel could destroy a large portion of the salmon fishery resource which has become famous throughout the world for both its quality and quantity.

The 1957 wholesale value of the Fraser River salmon industry has been placed at $34.5 million of which $21 million was collected by Canadian fishermen while the remaining $13.5 million went to their American counterparts.

Much has been said about the possibilities of passing the migrating fish upstream over dams or the fingerlings downstream without damage or delay; but even where fairly elaborate facilities do exist in other parts of the world they are in many instances of limited capacity and often of doubtful value. In the case of the Fraser at the proposed Moran damsite it is estimated that maximum upstream migration could reach 750,000 fish per day. This mass of fish or a large portion of it would have to be lifted several hundred feet depending upon

Fig. 3. Design Flood Diagram.



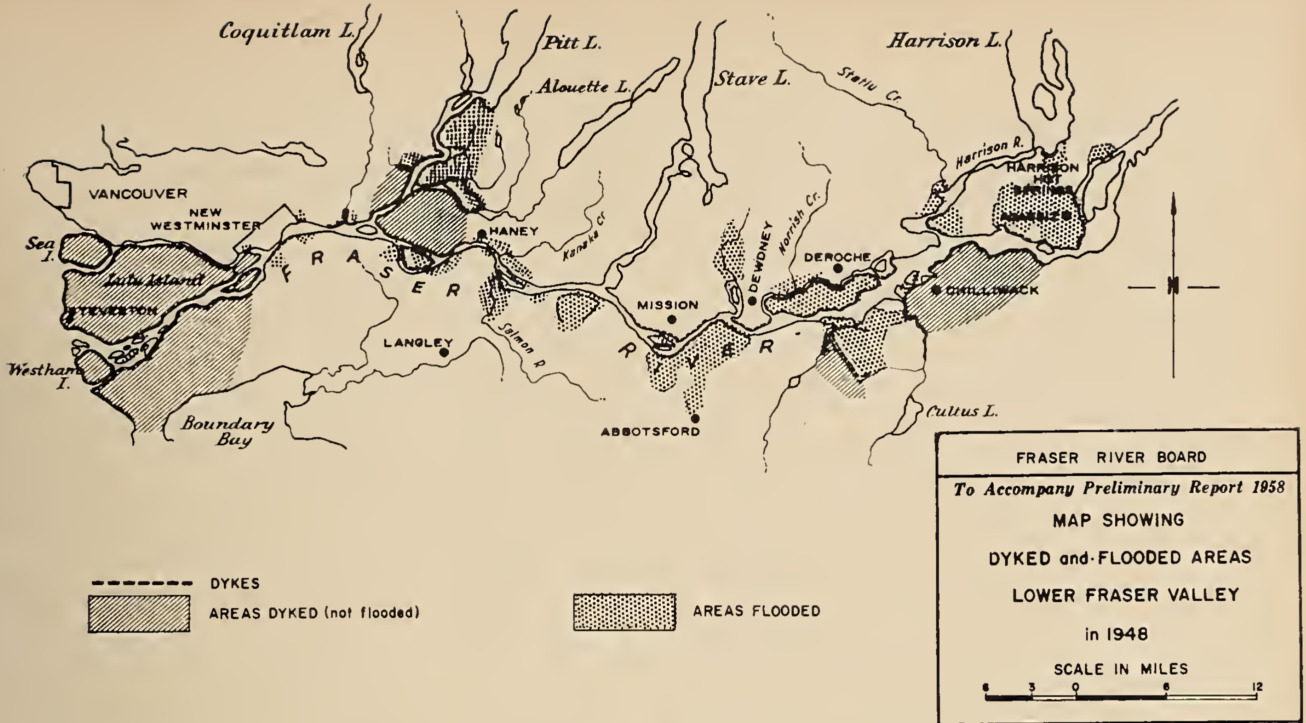


Fig. 4. Dyked and Flooded Areas Lower Fraser Valley.

the height of dam chosen.

At present there is no fish structure approaching this magnitude or capacity in operation. Other factors present themselves such as changing water temperatures, flooded spawning beds, etc. which are detrimental to fish propagation. These conditions and a number of others which would result from flood control and hydro-electric operations are receiving the attention of the fishery experts today both in the field and in the research laboratory.

Partial Development: The Board in recognition of this major problem and also the need for an early solution to flooding came up with three partial developments of the major systems which would:—

1. provide flood control to non-damaging levels in the Lower Fraser Valley;
2. form an integral part of a comprehensive plan for the basin in which all economical power sites would be fully developed;
3. be compatible with maintaining anadromous fish runs; and
4. be economically self-supporting through power production.

System A which is a partial development of System 3 probably approaches most closely the four objectives. Very briefly, it consists of five dams on the Clearwater, three on the Cariboo, one on the McGregor, one on the Upper Fraser east of Prince George and one on Stuart Lake. These in themselves would generate only about 1/7th of the total energy that would be realized from the full development of System 3. Nevertheless it would be an appreciable addition to the installed hydro-electric capacity within the Province. The return from the energy sales would about balance the carrying charges plus operating costs based on a capital cost of $521 million. Again, the benefit-to-cost ratio improves when such advantages as flood control are considered.

A modification of System A would require that the dykes be brought up to the original standards that existed at the time of their completion in 1950, thus eliminating the need for the Stuart Lake dam. The estimated cost of this improvement has been placed at $4.5 million.

Thus out of the Fraser River Board's preliminary report of 1958 has come a tentative plan for flood control in combination with the production of hydro-electric energy, with returns from the latter providing sufficient funds to cover the annual charges and operating costs.

It should be emphasized at this point that foundation conditions at the various damsites are for the most part unknown, and no doubt subsequent field explorations which are now under way will modify or change completely the preliminary plans that have been prepared.

Preliminary Investigation Problems

Within the limits of the interim and preliminary reports already outlined it might be instructive to describe briefly some of the problems met in investigating the Fraser River Basin to date.

Actually, in terms of multiple water use, only those dealing with flood control and hydro-electric power and their effects on the fishery industry have received detailed attention. This points up the difficulty of attempting to cover the broad field of water resource use in relatively undeveloped watersheds such as the Fraser.

For this reason the approach has been to plan on the basis of one or two of the more critical uses and then to modify the system as other considerations are introduced. In this respect, the interim report dealing with flood control through upstream retention reservoirs was modified by the introduction of hydro-electric power facilities. Economic analysis in turn pointed up the most efficient grouping and from this, particular developments were selected which provided the four main objectives.

The continuing broadening scope of the investigations brought with them demands for more and better information on a variety of subjects some of which are described briefly in the following pages.

The lack of basic data in meteorology, hydrology and topography and other physical phenomena is probably the most common complaint of engineers concerned with water resource investigations and the Fraser River Basin is no exception.

While the physical conditions such as topography and geology can be obtained as rapidly as funds will permit, it is not possible to suddenly acquire some 10 to 15 years of climatic and hydrologic data in areas where such observations have not been made.

Generally in a river basin at least 10 yr. of continuous temperature, precipitation and stream flow records are considered desirable for water resource studies. For this reason an early appreciation of the meteorological and hydrological requirements of a basin should be carried out followed by the establishment of stations in critical areas where such information is lacking.

Usually it is not posible to wait until all the hydrological and meteorological stations have "come of age" before preparing any reports and probably such a procedure would not be desirable. In fact, the early interpretation of existing data into report form will, in itself, stimulate group thinking and possibly point up errors or gaps in the existing program.

Meteorolgy: Ideally, meteorological data within the Fraser River Basin should reflect weather conditions as they occur in the various sub-drainage areas. Moreover, this representation in any particular region should provide climatic information at various altitudes extending from the valley bottoms up to the higher elevation snow fields.

However, such information can only be collected where there are observers to record it or at least to service self-recording instruments at frequent intervals. For the most part the settled areas of the Fraser are within the valleys below the 3,000 ft. elevation. It is not surprising therefore to find that only 16% of the meterological stations are above this altitude. In fact Barkerville, one of the key points in temperature studies, is the highest station in the watershed and at altitude 4,180 is only 400 ft. above the mean watershed elevation.

An indication of the lack of representative precipitation data is evident when the mean runoff at Hope of 16.2 in. is compared to an average precipitation of 31.5 in. obtained from an isohyet map. Obviously the latter should be much higher to produce the recorded runoff.

The lack of precipitation data for higher altitudes exists within all the main watersheds of British Columbia as well as the mountainous regions of the northwest States. It was one of the reasons for the establishment of snow survey courses first in the Columbia River Basin on the American side and eventually in 1935 in the Canadian portion of the same watershed.

The introduction of snow survey courses into the Fraser Basin was somewhat later, although today there are 25 snow courses ranging in elevation from 2,250 ft. at Blue River north of Kamloops to 6,300 ft. at Alberta Mountain near the headwaters of the North Thompson.

Near the end of each winter month starting in January, core samples are taken at marked points using aluminum tubes, and the snow moisture content is obtained. It has been found that as winter progresses the snow moisture content increases from the usual 10% figure up to 40 to 45% by the end of March which is generally considered the end of the snow accumulation period. On or about this date all main snow courses are sampled.

For predominantly snow fed rivers such as the Columbia and Fraser it has been found that the moisture content of the higher elevation snow fields about the end of March can be correlated with the total volume runoff which occurs during April to July or April to August, inclusive. Thus, where 10 or more years of snow moisture records are available to-

Fig. 5. Location of Sites under System A.

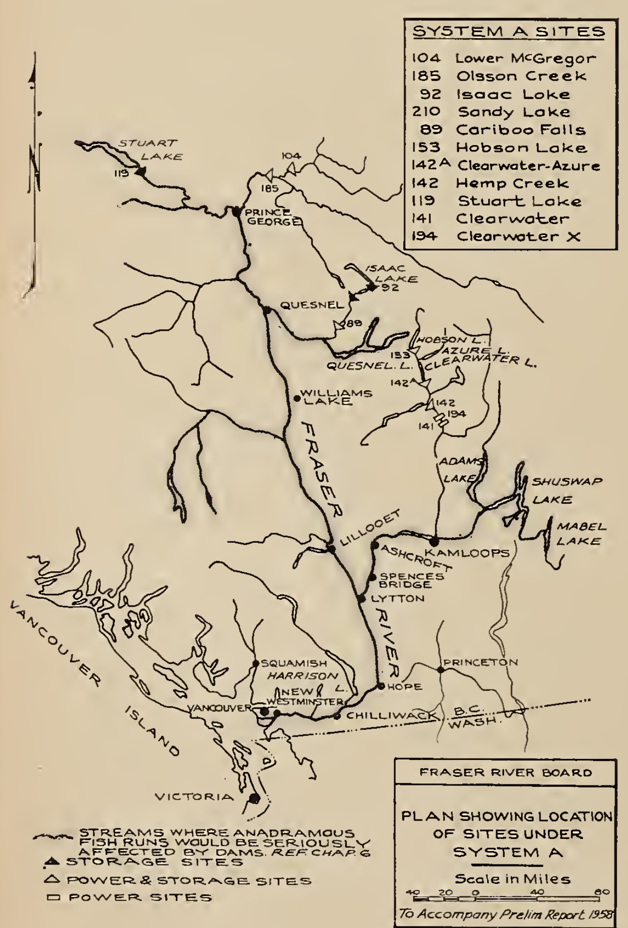
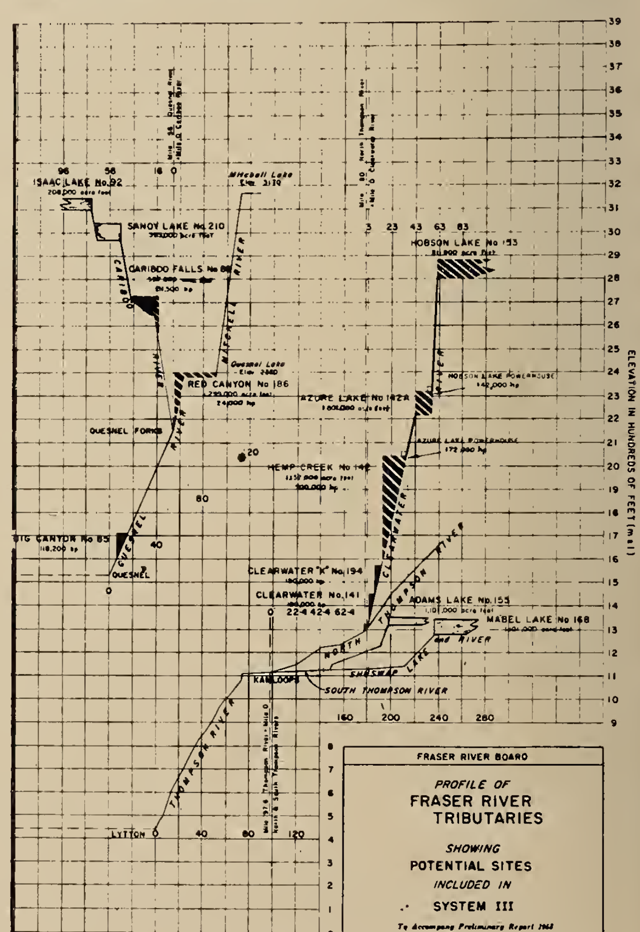


Fig. 6. Profile of Fraser River Tributaries Showing Potential Sites Included in System III.



gether with the corresponding summer volume discharges of the watershed, it is possible from snow sampling to predict the following 4 or 5 months of runoff. However, while this procedure provides the probable volume of the summer hydrograph, no reliable method has yet been found to predict the peak flow.

Only 3 of the 25 snow courses within the Fraser River Basin have been sampled for more than 10 years, the desirable minimum period. Tentative correlations, therefore, exist until further records become available. Nevertheless, from some 20 or more years of Columbia River records in the Canadian portion of the watershed volume runoff predictions have proven extremely reliable.

The ultimate in flood forecasting would, of course, be the prediction of the peak flow and its probable time of occurrence. In other words, the shape of the flood hydrograph at various points throughout the watershed would be anticipated a number of days in advance.

This is actually done to a very limited extent now through the observations of rising stages upstream which are flood routed downstream allowing a prediction of the river levels a few days in advance.

However, a complete flood warning system would go beyond this by actually providing the expected inflow into the various upstream tributaries several days in advance.

While such a program would be desirable under existing conditions, it would become almost imperative if a system of flood control and power dams were built on the Fraser River.

Snow melt runoff computations require up-to-date information on a number of factors, the main ones being snow moisture content and existing and expected maximum and minimum temperatures in the various snow fields betwen elevations 4,000 and 7,000 ft. The relationship between degree-days above freezing and runoff would be the basis for the inflow calculations, probably modified by such factors as soil moisture conditions.

Unfortunately, daily snow field temperatures are not available because of the lack of higher meteorological stations in the watershed. It is possible that remote control stations may, in the future, transmit continuous temperature readings from snow courses and the meteorologist in turn will be able to make detailed forecasts of expected maximum and minimum temperatures at those higher elevations. This, together with similar information on snow moisture content, should provide the hydrologist with a basis for inflow predictions.

In the meantime, the most representative data available of the Fraser watershed snow field temperatures are those taken daily at Barkerville. Another promising source may be the free air temperature obtained at approximately 5,000 ft. by the Department of Transport radiosonde equipment at such stations as Prince George airport. It is possible that there may be a good correlation between these free air temperatures and those in nearby snow fields at about the same elevation although to date very little research has been done on this.

Hydrometric Data: Hydrometric stations which provide stream discharges and river and lake levels do not present as many problems in their location as do meteorological stations. However, in the sparsely settled northern portion of the watershed there are difficulties in obtaining observers.

Some of the key stations along the old railway belt such as the Fraser at Hope and the Thompson at Kamloops were established back in 1912, whereas the Upper Fraser stations, where one third of the 1948 flood originated, have only been operating since 1950. In fact, out of a total of 63 continuous gauging stations on the Fraser River today, about ⅓ have less than 10 years of record.

In many instances correlations had to be resorted to between newly established and long term stations in order that the watershed could be studied over a continuous 20 yr. period from September 1928 to August 1948.

Also in a number of the tributary watersheds, lake systems made up a substantial portion of the watershed and while outflows from these natural reservoirs had been recorded for a number of years no daily lake level readings were available to compute inflows.

Again, at many of the proposed damsites stage-discharge relationships had to be established to provide tail water curves for power analysis.

In one important study to check the 1894 peak discharge a correlation was carried out with the Columbia River at The Dalles where records were available back to 1858. It is interesting to note that the peaks of the two rivers frequently occur within a few days of each other, and, since the two watersheds have somewhat similar characteristics and both are predominantly snow fed streams, it might be expected that they would reflect parallel conditions.

The coefficient of correlation for the peak flows was found to be 0.72 and from the regression equation established, it was found that the 1894 flood of 1,240,000 c.f.s. recorded at The Dalles on the Columbia on June 6 was equivalent to 502,000 c.f.s. on the Fraser at Hope with possible extreme values varying between 389,000 c.f.s. and 615,000 c.f.s. Obviously the 600,000 actually chosen is very liberal according to this analysis.

Another difficulty arises in attempting to determine the probable frequency of the design flood. Its three variables, magnitude, volume and duration above 250,000 c.f.s. can be assigned re-occurrence intervals but the frequency of such a combination occurring is hard to establish.

Topographic Data: Early in the Board's history it was recognized that a major portion of the watershed was not adequately mapped and from 1949 onward an almost continuous program of air photo mapping was carried out. Today there are topographic map sheets available of all the reservoirs at scales varying between 1/6000 to 1/12000 on which either 20 or 40 ft. contours have been shown. In the case of damsite surveys the plotting scale was increased to 1/1200 to 1/2400 on which 10 ft. contours were drawn. Also through all navigable portions of the river including a number of canyon sites bathometric surveys have been carried out.

Mapping for preliminary investigation work requires early agreement by all interested parties as to the details needed for it is from this, particularly the contour interval, that the scale is determined.

It can be argued that topography which defines reservoir volumes need not be any more accurate than the hydrometric data available. On the other hand, where the mapping is used for the determination of flood damage, the re-location of communication lines, and benefit cost studies, much more detailed and accurate information may be desirable.

Erosion and Silting: In a Province such as British Columbia where the major portion of the population and lines of communication are within the valley bottoms, the people are very conscious of erosion and silting.

From a flood control and hydroelectric point of view it is also important, for heavy silt laden waters can reduce storage capacities within the reservoirs. Again fluctuating high water levels behind dams can cause silt banks to fail. Even today, with no artificial obstructions, slides do occur along the Fraser particularly in the interior plateau country. It is this sloughing during the flood period which creates what appears to be a

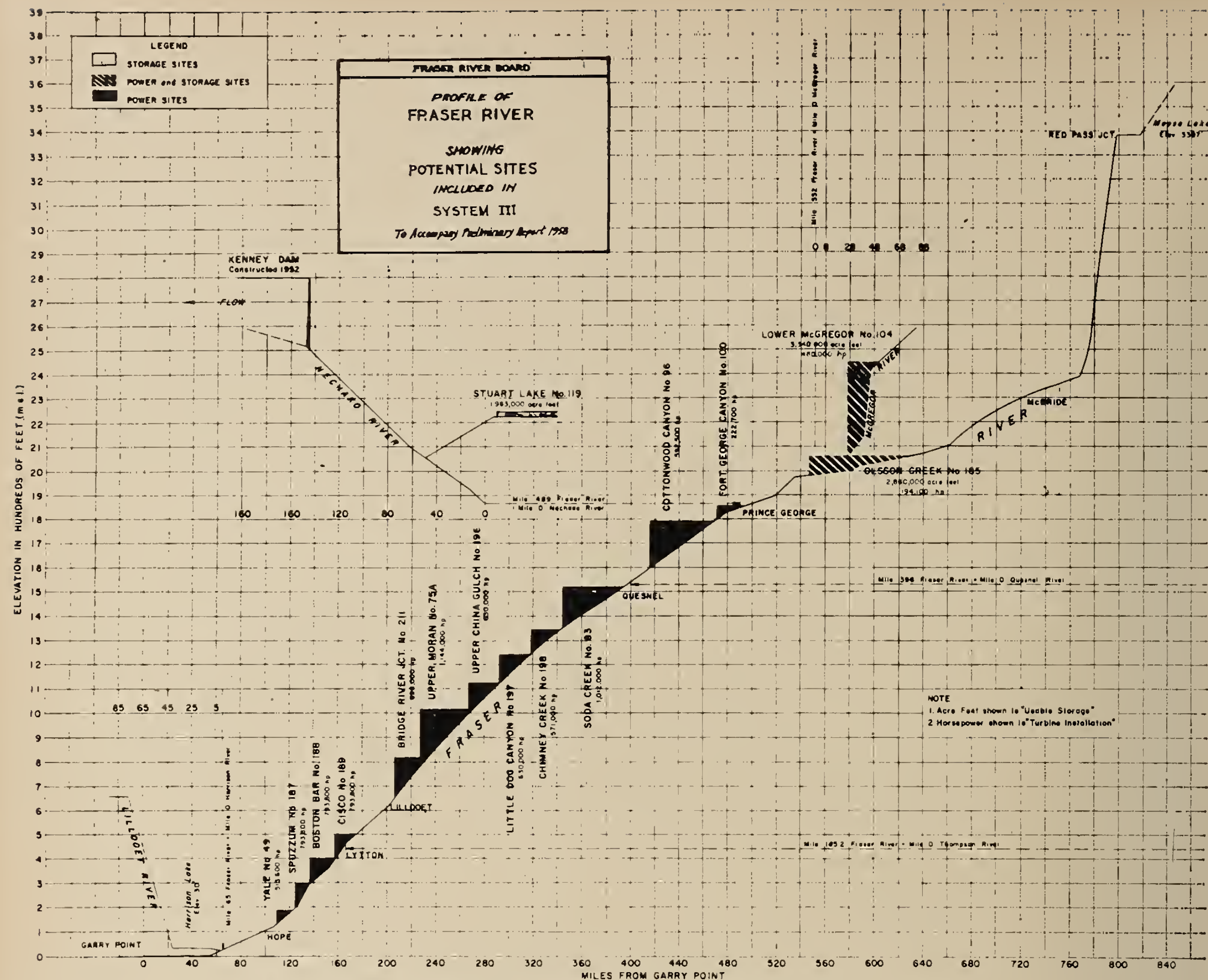


Fig. 7. Profile of Fraser River Showing Potential Sites Included in System III.

very silt laden water.

In order to arrive at a measure of load transported by the river a suspended sediment sampling program was carried out along the main stem of the Fraser during the period 1949 to 1952 using a P-46 point integrating sampler.

For the three years of record from 1950 to 1952, inclusive, it was found that a large proportion of the suspended sediment discharge at Hope occurs during the high flow months of May, June and July reaching a maximum value of 500 to 800 p.p.m. just before the peak occurs and dropping to a low of 20 to 50 p.p.m. during the fall and winter.

In terms of volume the annual average suspended sediment discharge at Hope for the three years of record is 10,600 acre ft. or 12.4 acre ft. per 100 sq. miles of drainage area. For comparison, the Colorado watershed carries about 10 times this load per sq. mile.

The suspended sediment concentration of the Thompson River on the other hand is only about 1/10 that of the Fraser due to the settling effects of Shuswap and Kamloops Lakes.

No attempt to date has been made to measure the bed load of the river although from regular soundings below Hope its movement shows up in the form of sand waves which appear to progress downstream with each freshet.

With this limited information it is rather difficult to predict just what effect a series of storage reservoirs upstream of Hope might have on the regime of the lower Fraser. No doubt the higher fall and winter flows would assist navigation. On the other hand it is at these medium flows that some of the greatest erosion occurs particularly along some of the dyked areas.

Dyking and Drainage: So far the problems discussed dealt with the natural physical conditions within the Fraser River watershed. However, as noted early in this paper, the lower valley is protected from flooding by a system of dykes.

These dykes afford protection to the heavily populated areas and while they were designed to retain the greatest known flood, this protection has been appreciably reduced due to aging and lack of maintenance.

Tributary drainage through the main dykes is handled by gravity flow through culverts equipped with flap gates while at highwater the inflow is pumped over the dykes.

While the spring flood can create critical conditions in the lowlands behind the dykes, a further and sometimes more serious threat can occur in the fall and winter when heavy rainstorms penetrate the lower valley resulting in as much as 12 in. of precipitation in a 3 to 4 day period. Generally pumping facilities to handle such inflows are not sufficient and local flooding occurs.

This condition would be further aggravated if increased channel capacity were realized through the raising of the dykes and this in itself is an argument for upstream storage. Thus, it would be better to stop the waters near their source rather than to attempt to control them in the Lower Fraser Valley.

(Continued on page 84)

ALUMINUM IN ROLLING STOCK;

Hopper Cars on the Roberval and Saguenay Railway

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Canada has led the world in many developments in aluminum in railway rolling stock; a significant one has been the world's first all-welded aluminum open hoppers brought about by the combined efforts of Canadian Car Company, Limited, Aluminium Laboratories Limited and The Roberval and Saguenay Railway Company. Thirty of these cars went into service in May 1957 at Arvida, Quebec and were an addition to 118 open hopper cars with aluminum bodies already in service. Although aluminum hopper cars have been used since 1931, these thirty resulted from many technical achievements in prototype building and testing car design, car shop techniques, alloy developments, welding developments and techniques, extensive shake-out tests and impact tests at collision speeds.

Introduction

THE WORLD'S FIRST welded all-aluminum open hopper cars went into service in May 1957 at Port Alfred, P.Q., carrying bauxite on the 20-mile haul to the Aluminum Company of Canada, Limited smelter at Arvida. Built for The Roberval and Saguenay Railway Company (R.&S.) by Canadian Car Company, Limited, Montreal, the 2300 cu. ft. capacity cars offer several technical advances in design and construction. They are eight tons lighter than steel cars and have a payload to deadload ratio of 5.5 to 1. Delivery of the thirty cars in the latest order (May 1957) brings to 148 the number of aluminum hopper cars being operated by the R. & S.

The R. & S. Fleet

The Roberval and Saguenay Railway Company own and operate 213 open hopper cars which can be separated into five categories:

a) Forty-six of the cars have been in service for over 25 years. They are steel cars of 50-ton capacity with 30° slope sheets and a light weight of 39,000 lb;

b) Ninety cars with aluminum bodies and steel underframes. These cars are of riveted construction with 30° slopes and a light weight of 36,000 lb. They were built between 1948 and 1951 and are a direct conversion from existing steel designs;

c) Nineteen of the cars were built in steel by the R.&S. since 1947. They have 40° slopes, have a capacity of 70 tons and a light weight of 48,000 lb. They are a new concept of car design and led to;

d) The R.&S. 1300 Series with a light weight of 36,600 lb. There are twenty-eight cars in this series with welded aluminum bodies, 40° slopes and steel underframes. They were the first welded aluminum open hopper cars ever built. These were the forerunners of;

e) The R.&S. 1400 Series with a light weight of 32,400 lb. There are thirty of these cars. They are all-aluminum with 40° slopes and are the first welded aluminum open hopper cars ever built with a welded aluminum underframe.

History

Early Riveted Designs — Hopper cars have been made with aluminum bodies since 1931, when the Aluminum Ore Company put ten into service in the United States. In the succeeding years several U.S. roads followed suit. By 1945 Pennsylvania, Texas & New Orleans and Baltimore & Ohio each had one car in service. In 1944 Burlington put an aluminum-sheathed hopper car into service, followed by Missouri Pacific with twenty-five aluminum-bodied cars and Montana with one aluminum body and underframe car. Later, Illinois Central and Chesapeake & Ohio each built five aluminum body cars, and Southern undertook a rebuilding program using aluminum. (See Table I).

Aluminum hopper cars made their first appearance in Canada in 1948 when The Eastern Car Company, Limited of Trenton, Nova Scotia, built thirty cars for The Roberval and Saguenay Railway Company. These hopper cars, numbered R.&S. 932 to 961, were a direct conversion from the steel A.A.R. Class HT 70-ton triple hopper car of 2775 cu. ft. capacity with 6 in. x 11 in. journal. (See Fig. 1). These open-bodied cars were made from Alcan 65S-T6 plate and extrusions joined with Alcan 55S-T6A rivets. The sides were 3/16 in. thick sheet and the slopes and hoppers were ¼ in. thick plate. In joining the side sheets, slope sheets and shapes, ⅜ in. diameter rivets were used. The centre sill, body bolsters and crossbearers were steel. The weight saved per car was 12,000 lb., compared to a standard steel car. This was obtained by employing 6500 lb of aluminum, resulting in a light weight of 36,000 lb and a load limit of 174,000 lb. To make these light cars suitable for interchange, they were equipped with Westinghouse "ABLC" brakes.

Fifty cars of the same type were purchased in May 1949 and were numbered R.&S. 1200 to 1249. In view of trouble caused by the "ABLC" brake mechanism becoming fouled with bauxite dust, these cars were equipped with straight "AB" brakes.

During the open season of navigation these and the above thirty cars are loaded and unloaded as much as three times every two days under a Hewitt-Robins Car Shake-Out. To resist the effect of the vibration, to carry the load of the shaker and to generally strengthen the side plate, additional 6 in. x 6 in. x ⅝ in. angles were riveted to the top of the cars directly over the diagonal braces at the cross ridges. With this modification the cars are to date performing satisfactorily.

In August 1951 ten more cars, numbered R.&S. 1250 to 1259, were placed in service. Except for minor modifications, these cars were similar to the previous cars. Early in 1952 the Canadian National Railways purchased five cars of this construction.

The New Concept—A new concept of car construction and a design especially suited to hauling and unloading bauxite was initiated by Mr. R. Cabana of The Roberval and Saguenay Railway Company. In 1947, using trucks and centre sills from cars whose bodies had been scrapped, two prototype steel cars were built. These triple hopper cars are 70-ton capacity with 6 in. x 11 in. journals. There are no side posts except for the bracing at the cross ridges, and a 40° slope rather than 30° was used on the slope sheets and hoppers. The bodies were built using 3/16 in. steel side and ¼ in. thick steel slope sheets. The side plates are about twice as strong as those used on a standard 70-ton steel triple hopper car and great care was taken to apply the side sheets in such a way as to give continuity from end to end of car.

With 40° slopes and no inside posts, the bauxite flows much faster from these cars than from 30° slope cars. At 2000 cu. ft. capacity, the cars are ideally suited to carrying bauxite which requires 1800 cu. ft. for a full axle loading of 210,000 lb, with a car weight of 48,000 lb. The density of bauxite is 90 lb per cubic foot.

By 1954 the R.&S. had built and operated sixteen such cars and were satisfied that the prototype cars were entirely satisfactory for their operations.

More cars were required and the car companies were requested to quote on steel and aluminum cars of this new design.

The Aluminum Company of Canada, Limited undertook to study this new design concept as it applied to aluminum. The latest known developments in aluminum alloys, design of shapes and economical fabricating practices were reviewed. A stress analysis was made and the studies indicated that this concept could be applied to construct a welded aluminum hopper car designed from first principles.

Welded Hopper Cars—In July 1955 the Canadian Car Company delivered to the R.&S. the first welded open-bodied aluminum hopper cars ever produced. The cars are known as the R.&S. 1300 Series. They are triple hopper cars of 2200 cu. ft. capacity with 6 in. x 11 in. journal. They are equipped with Westinghouse "7⅞ in. x 12 in. Empty and Load Fully Automatic Brakes". The weight saved was 11,400 lb, giving a light weight of 36,600 lb. Although 8000 lb of aluminum was used, which was more than in the previous ninety cars, the total dollar value of the aluminum was less. Thicker plate was used, but it was confined to one gauge. The only pressings were the hopper doors. Only five different shapes were used in the car, of these four were standard

TABLE I

Aluminum Open Hopper Cars

Date Built	*Owner*	*No. Cars*	*Type*	*Ratio Load Lt. Tare Wt.*	*Nominal Capacity Tons*	*Capacity Cu. Ft.*	*Wt. of Car Pounds*	*Load Limit Pounds*
1931	Aluminum Ore Co.	10	c	4.4	70	2,475	38,900	171,100
1932	Pennsylvania	1	b	4.4	50		31,300	137,700
1934	Texas & New Orleans	1	a	3.3	70	2,051	48,100	161,900
1934	Baltimore & Ohio	1	c	5.1	50	2,450	27,700	141,300
1944	Chicago Burlington	1	a	3.6	55		36,800	132,200
1945	Missouri Pacific	25	b	4.6	70	3,000	37,000	173,000
1946	Montour	1	c	4.7	70	3,000	36,500	173,500
1948	Illinois Central	5	b	3.5	50	2,230	37,500	131,500
1948	Chesapeake & Ohio	5	b	4.5	50	2,053	30,800	138,200
1948	Southern	2			55			
1948	Roberval & Saguenay	30	b	4.8	70	2,775	36,000	174,000
1949	Roberval & Saguenay	50	b	4.8	70	2,775	36,300	173,700
1951	Roberval & Saguenay	10	b	4.8	70	2,775	36,000	174,000
1952	Canadian National	5	b	4.8	70	2,775	36,000	174,000
1955	Roberval & Saguenay	28	b	4.7	70	2,200	36,600	173,400
1957	Roberval & Saguenay	30	c	5.5	70	2,300	32,400	177,600
	A.A.R. Steel			3.2	50	2,145	40,000	129,000
	A.A.R. Steel			3.3	70	2,773	48,800	161,200

TYPES: (a) Aluminum Sheathed
(b) Aluminum Body
(c) Aluminum Body and Underframe

Fig. 1. Inside View of 70-ton Open Hopper Car with Aluminum Body. 30 cars of this type were built in 1948, 50 in 1949 and 10 in 1951 for the R.&S.

shapes and only one, the extra heavy side plate (see Fig. 2), was especially designed for the car.

These cars proved very satisfactory in service, requiring no body maintenance. Extensive shake-out fatigue and impact tests at collision speeds revealed a minor weakness in the diagonal side braces which may never fail in service.

During the latter part of 1956 impact tests showed that a welded aluminum centre sill, under dynamic loads, meets the proposed design requirements of the Association of American Railroads (A.A.R.). The carbuilders then felt free to use a welded aluminum centre sill for new construction.

In April 1957 the Canadian Car Company delivered thirty of the first all-welded, all-aluminum open hopper cars with welded aluminum centre sills to the R.&S. These triple hopper cars, known as the R.&S. 1400 Series, are 2300 cu. ft. capacity with 6 in. x 11 in. journals. The bodies, with the exception of an increased cubic capacity and a modified diagonal side brace, are the same as the previous twenty-eight cars. The centre sill, body bolsters and crossbearers are of welded aluminum construction. The weight saved per car is 16,000 lb, giving a light weight of 32,400 lb and a load limit of 177,600 lb, or nearly 89 tons. 11,000 lb of aluminum was used per car.

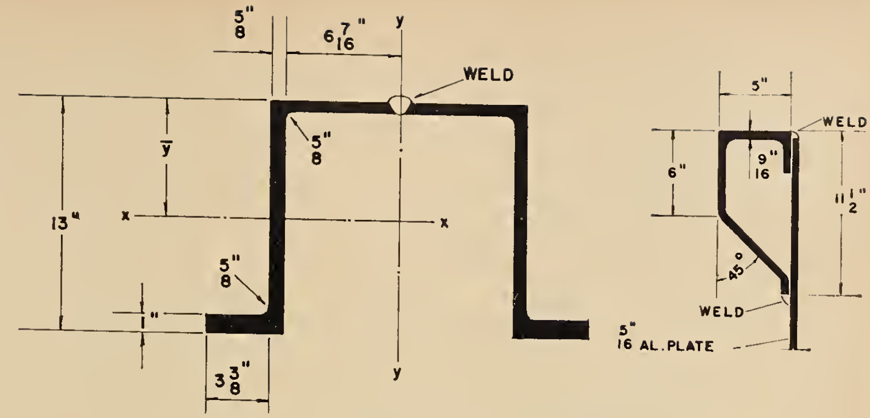


Fig. 2. Centre Sill and Side Plate Extrusion

A.A.R. Proposed Requirements (DV 400) For End Loading

Ultimate Load	1,000,000 lb.
Yield Load	500,000 lb.
Design Load	250,000 lb.

Mechanical Properties — Guaranteed Minimum

Tensile Strength	38,000 psi
Yield Strength	35,000 psi
Elongation	10 %

Properties of Sill Section

$A = 29.8$ in^2 $\quad Ix = 734$ in^4
$\bar{y} = 6.51$ in $\quad Iy = 1368$ in^4
weight = 34.9 lb./ft.

Side Plate Section
$A = 10.3$ in^2
Weight = 12.36 lb./ft.

Design Considerations

In designing the R.&S. 1400 Series of aluminum welded hopper cars, the following factors were given consideration:

(1) *Weight Distributions* — The estimated weight of the car was 32,500 lb (16.25 tons) with a load limit of 177,500 lb (88.75 tons). It was estimated that these weights would be distributed with half the load carried by the centre sill and the other half by the sides. The centre sill is supported by the two trucks and the two crossbearers. The crossbearers, by supporting the centre sill, transfer about 20% of the total load from the centre sill to the car sides. This increases the load carried by the car sides to about 70%, which load is transferred through the body bolsters to the trucks. The remaining 30% is transferred directly from the centre sill to the trucks.

(2) *Design of Car Sides* — The angle of repose for bauxite is 35° and its density is 90 lb per cu. ft. The horizontal pressure was calculated by the Rankine formula. The resulting horizontal pressure is distributed by membrane action to the surrounding framework.

The shearing force in the sides is distributed by means of diagonal tension to the top and bottom chords. As the car is frequently unloaded under a car shake-out, the two vertical stiffeners were reduced to the minimum to make the car more elastic than conventional cars. Several stiffeners would make the sides rigid and create several stress concentrations. With only two vertical stiffeners, the load carried by the top chord (side plate) and bottom chord (side sill) is much greater than the load carried by these members in conventional cars with vertical stiffeners at about 3 ft. 6 in. intervals.

The bottom chord is a 5 in. x 3½ in. aluminum angle. The top chord is a specially designed box section. (See Fig. 2).

(3) *Buffing Load*—The A.A.R. proposes that buffing loads of 1000, 500 and 250 kips shall be taken by the centre sill based on its ultimate, yield and working stresses. An aluminum centre sill was designed to this requirement. This sill, like the A.A.R. steel centre sill, is made by welding two Z sections. (See Fig. 2). In designing the centre sill, the eccentricity of the load was taken into account. The welded area, as well as the heat affected zone of the centre sill, was not included in the effective net area.

(4) *Shifting of the Lading Due to Buffing Load*—The shifting of lading, which invariably takes place with materials such as bauxite, imparts stresses to the body, the underframe and the connections between them. A flexible type of construction was adopted to absorb these stresses.

(5) *Unloading*—To unload the car efficiently with a shake-out machine, it was necessary to permit the components of the car to vibrate to a maximum amplitude without causing undue strain on the connections. The high amplitude, combined with 40° slope sheets, reduces the shake-out time and the car damage.

Materials

Corrosion Resistance—The successful performance of aluminum alloys in open hopper cars has been demonstrated on both practical and experimental grounds. From a practical point of view, there is ample proof of corrosion and abrasion resistance in the excellent performance of the 148 open aluminum hopper cars (Alcan 65S and Alcan B54S) now being used at Arvida by the R.&S. mainly to carry bauxite, but also in coal, coke and fluorspar service. Supplementing this is the experience of the Dominion Steel and Coal Corporation, which has been using aluminum in mine cars (Alcan 65S) in their coal mines since 1947; over 1200 aluminum mine cars are now being operated without corrosion problems. From an experimental point of view, convincing proof of aluminum's ability to withstand the ravages of corrosion has been standing in an Aluminum Company of America test yard near Pittsburgh since 1932. The proof is in the form of an aluminum hopper car body, which is still in good condition after having been standing in the weather, loaded with different grades of sulphur-bearing coal over all these years.

Aluminum Alloys—The aluminum alloys used on the ninety riveted hopper cars were Alcan 65S-T6 sheet and plate and Alcan 55S-T6A rivets. Alcan 65S-T6 sheet and plate have a typical yield strength of 40,000 psi. These alloys are suitable for riveted structures but as such cannot be fabricated as cheaply as steel.

A significant advance has been the development of Alcan B54S, in the fabrication of which new high-speed welding techniques can be employed. Furthermore, high-speed production jigs formerly used for steel production can be used in welding the new aluminum alloys simply by changing the welding units.

Tables II and III show the properties that are prevalent in the R.&S. 1300 Series.

TABLE II

Mechanical Properties of representative Samples of the 5/16 in. B54S-H11 Plate Used in R. and S. 1300 Series.

Sample No.	*Weight of Plate Represented by Sample*	*Tensile psi*	*Yield psi*	*Elongation % in 2"*
1	49,140	39,590	28,530	27.0
2	40,950	40,800	32,900	21.5
3	45,360	40,000	28,350	22.5
4	7,560	41,100	28,600	23.0

Fabricating Advances

Riveting—A great deal of valuable experience has been gained since 1931 in fabricating aluminum for open hopper cars and other rolling stock applications. Many deficiencies in fabricating techniques were realized and overcome. One of the greater difficulties has been the necessity to cold drive aluminum rivets in order that satisfactory strengths might be developed in the riveted joints. The rivets used in Canada are Alcan 55S-T6A, for which the minimum guaranteed shear strength prior to driving is 20,000 psi and the ultimate tensile strength is 30,000 psi. On a high-speed production line, which exists in freight car manufacturing shops, the cold driving of Alcan 55S-T6A rivets by hand is a burdensome task and results in slowing down the production line. Unfortunately, it is impractical to heat the rivets because controls of the required accuracy are too costly to install and operate in a car shop. Heating with equipment usually available causes the rivets to become annealed, with resultant loss of properties to 7,500 psi yield strength and 17,000 psi ultimate tensile strength, or brings about an embrittling effect due to incipient fusion which also gives properties greatly inferior to those in the annealed condition.

Fig. 3. A mammoth jig which, with automatic welding equipment, is used to weld the aluminum side sheets to the aluminum side plate and side sills.

This problem has been overcome by the introduction of welding or by using a combined welding and riveting procedure.

Aluminum to aluminum structural joints are usually fabricated by welding. In those cases where a riveted joint is absolutely necessary, aluminum rivets up to ⅝ in. diameter are driven cold by hand using a low pan driven point, or if rivet diameter is above ⅝ in. they are usually driven by machine using cone points. If rivets above ⅝ in. diameter must be driven by hand, then hot driven steel rivets are used and these are later suitably primed and painted.

Aluminum to steel riveted joints are fabricated with hot driven steel rivets. The aluminum faying surfaces are primed with zinc chromate, the steel surface with a non-lead bearing primer and the joint insulated with a layer of car cement. The steel rivets are not treated prior to driving but are primed and painted after fabrication.

Other fabricating practices such as punching, shearing and drilling, are carried out according to well established practices and have not presented any difficulties.

Welding — Automatic aluminum welding was used for the first time in car construction when the R.&S. 1300 Series of open hopper cars were built. It was accomplished by a thorough study of aluminum, its weldability, modern welding equipment and existing jigs.

The car sides were designed to permit a maximum use of this high-speed technique. One Model "C" Aircomatic Head mounted on an Airco Welding Head Positioner and a Lincoln 600 amp D.C. Welder were fitted on the jigs. The side sheets made up of eight separate pieces were welded on one jig. The top and bottom structural members were welded to the sides on another jig. (See Fig. 3).

Other jigs and fixtures were built for manual welding using eight Sigma Welders SWM-2 Series 5 and eight A. O. Smith D.C. Rectifiers 400 amp.

The result was an entirely satisfactory car economically manufactured with the best carbuilding practices.

Building the R. & S. 1400 Series

The same equipment and techniques used in welding the R.&S. 1300 Series were used for the R.&S. 1400 Series. The structure was divided into the following sub-assemblies: (See Fig. 4.)

1. Centre sills
2. Body bolsters
3. Slope sheets
4. Hoppers
5. Sides
6. Crossbearers and transverse apex sheets
7. End framing

These sub-assemblies were fitted together by riveting and the joints completed by IMA welding.

1. *Centre Sills*—To weld the sill, an hydraulic jig used to weld steel centre sills automatically was equipped with Aircomatic automatic welding equipment. Alcan 56S electrode wire of 3/32 in. diameter was used. Two 400 amp Westinghouse rectifiers were used in parallel as the power source.

The following procedure was used:

1st pass—450 amp, arc travel speed 34 in. per min.

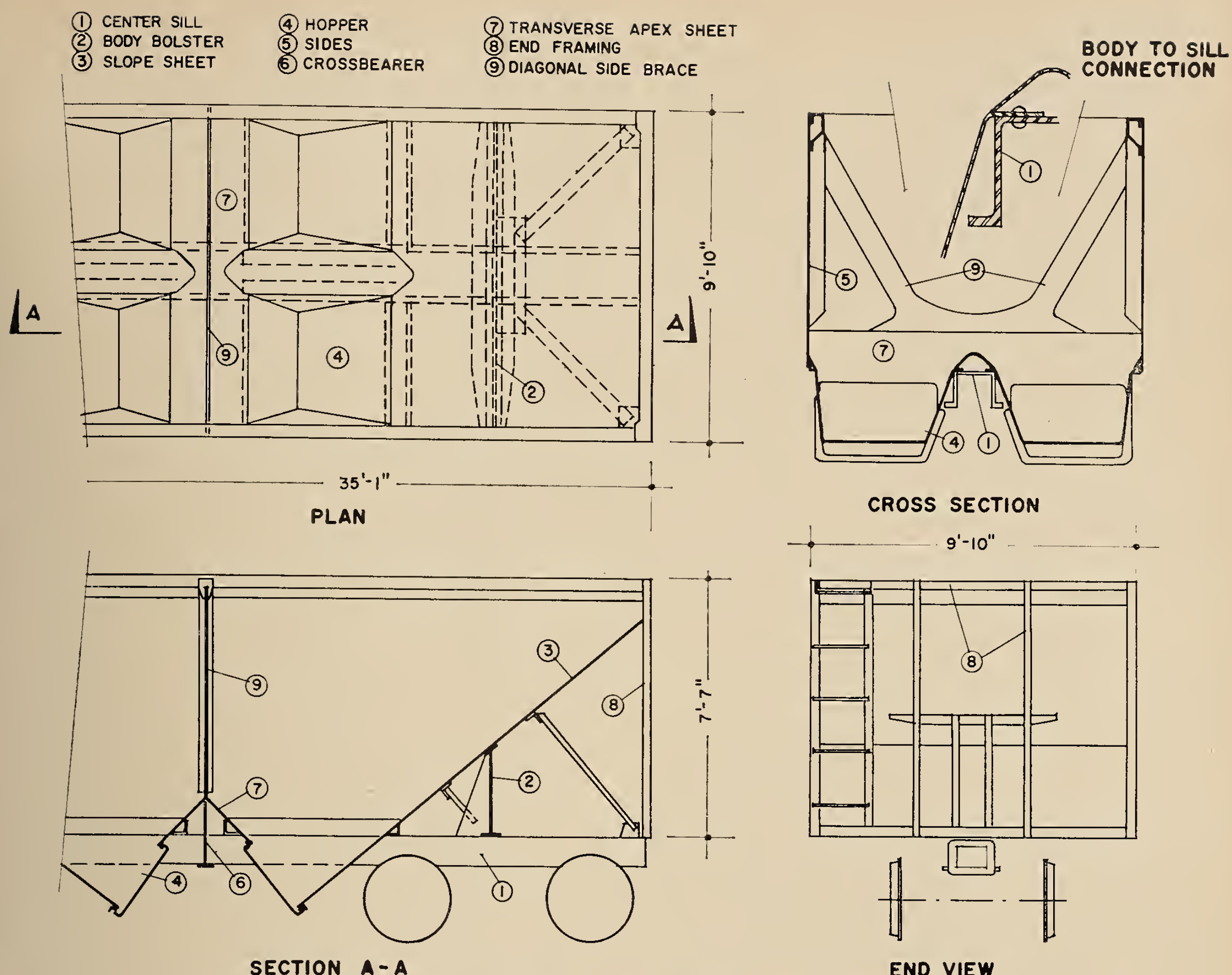


Fig. 4. R & S 1400 Series Hopper Car — General Arrangement

2nd pass—420 amp, arc travel speed 34 in. per min.

2. *Body Bolsters*—The body bolsters and crossbearers which included the transverse apex sheets were designed with vertical side flange plates butt welded to the webs so as to provide a riveted connection to the side sheet which would be independent of the variation in location between these members and the side posts. The material used in these members consisted of flat rectangular aluminum plates, some having a single V-die bend, IMA hand welded into a unit in a simple jig fixture.

3. *Slope Sheets*—Slope sheets consisted of large flat rectangular aluminum plates automatically butt welded into a unit, extending from the hoppers to the end plate. The connection between the slope sheets and the side sheets consisted of a simple T-butt welded erection joint, thus affording a large margin of variation with no additional difficulty in fitting and erection.

4. *Hoppers* — The hoppers were designed to match a standard cast steel Wine door frame, and to provide a 40° slope on the hopper bottom sheet. The flat aluminum hopper bottom sheet was butt-welded to the hopper side sheets in a small jig fixture. The hopper sub-assembly was completed by riveting the door frame to the weldment. The hopper side sheets consisted of triangular plates bent outwards to form a top flange for riveting to the centre and side sills. This provided adequate shear attachment of the hoppers to resist impact loads, without imposing a local high bending moment on the centre sill.

5. *Sides*—The side sheets consisting of eight 5/16 in. Alcan B54S-H11 rectangular aluminum plates was automatically welded together to form a continuous skin. A square butt

TABLE III

Mechanical Properties of the Materials Used in Hopper Car Construction.

Alloy	*Guaranteed Properties*			*Typical Properties*			*Welded Properties*			*Working Stress Used in Design*	
	Ultimate Tensile Strength psi	*Yield Strength psi*	*Elong. % in 2"*	*Ultimate Tensile Strength psi*	*Yield Strength psi*	*Elong. % in 2"*	*Ultimate Tensile Strength psi*	*Yield Strength psi*	*Elong. % in 2"*	*Non-Welded psi*	*Welded psi*
65S-T6	42,000	35,000	10	45,000	40,000	12	28,000	18,000	2	17,500	(i)
B54S-H11	38,000	19,000	12	43,000-42,000	31,000-25,000	20-23	40,000	20,000	16	10,000	10,000

(i) All welds in Alcan 65S-T6 in this hopper car are especially designed so that the full working stress of 17,500 psi can be used.

joint with 1/16 in. gap was employed. Welds were made automatically using 1/16 in. diam Alcan 56S welding wire. The eight plates were joined on one side, then turned over and welded from the other side for complete penetration. The current used was 300 amp, the voltage 30 and the welding speed was 35 in. per min.

The side sheet was in turn jig clamped to the side plate and the side sill for automatic welding. (See Fig. 3). The current used was 350 amp, the voltage 32 and the welding speed 36 in. per min.

The two side posts were welded by hand to the side sheet and side plate, however at the bottom these posts tapered away and were terminated at a point approximately 2 in. above the intersection of the crossbearer web. From this point downward to the side sill the side sheet was reinforced by welding a 7/16 in. triangular flat plate. This feature made it unnecessary to have an exact alignment between the side posts and the crossbearers during erection. It also eliminated the usual rigid connection between these members.

The crossbearer assemblies were jigged and welded by hand, as were the apex sheets and end framing.

Final Assembly—The erection of the car body was performed in the following sequence. The centre sill was clamped in position on a simple underframe jig and the body bolsters, crossbearers, end frames and other cross members were located in position on the sill and riveted thereto. This was followed by the application of the assembled slope sheets, which were riveted to the body bolsters and to a bottom cross member and clamped and welded to the top of the end frames. This arrangement provided the necessary flexibility, since a variation in distance between the cross members would only result in a slight change in the angle of the slope sheet. The structure was then ready for application of the hoppers, which were riveted in place to the centre sill, bottom of slope sheets and transverse apex sheets and then IMA hand-welded to complete the connection. On the final major assembly, the sides were hoisted into position by cranes and then bolted and riveted to the ends of the cross members. This was followed by clamping the side sheets, so as to bear tight against the edges of the slope sheets and then proceed to weld the full length of the side connection.

Testing

The R.&S. 1300 Series of cars was the first attempt at designing and building welded aluminum hopper car bodies with steel underframes. After these cars were produced, an aluminum centre sill, designed to meet the published requirements of the A.A.R., was produced. (See Fig. 2). Sixteen welded aluminum covered hopper cars for alumina service in Jamaica were built in early 1956 using this welded aluminum centre sill.

To prove the soundness of the design of the R.&S. 1300 Series and of the welded aluminum centre sill, a series of shake-out and impact tests was carried out. As a result, the R.&S. cars of the 1400 Series are equipped with essentially the same bodies as the R.&S. cars of the 1300 Series and have welded aluminum underframes.

Shake-Out Fatigue Tests — R.&S. car No. 1304 was taken out of service for shake-out fatigue testing.

A 6-ton Hewitt-Robbins car shake-out was operated at full capacity on the empty aluminum car body weighing 4 tons (excluding the steel bolsters, crossbearers and centre sill, the weight of which was 4 tons). In practice the aluminum welded cars are loaded to about 100 tons on rail and are unloaded using a similar shaker of lower capacity.

The Hewitt-Robbins car shake-out supplied an oscillating force of 3600 lb at a frequency of 24 cycles per second. Thirty-six SR-4 strain gauges were affixed to those locations on the car at which it was thought major stresses would occur. The strain indications were recorded using a Brush oscillograph.

The car shake-out was operated on the empty car for 20 sec. periods for the first 8 min., then at periods varying from 10 sec. to 10 min. for the remainder of the test. After each period the car was thoroughly inspected for damage.

The maximum alternating stress measured was about 8000 psi, it occurred both at the centre of the panel immediately under the car shake-out, and at the juncture of the top member where it joined the car sides, which was also immediately under the car shake-out. The large number of strain gauge readings provided sufficient information to give a relatively clear picture of the distribution of stresses and their frequencies throughout the car sides. Figs. 5 and 6 show the peak stresses that were recorded and their location.

A comparison of the performance of this aluminum car with that of welded steel hopper cars, tested under similar conditions, showed that aluminum performed as well or better than steel. As a result of these tests, the R.&S. 1400 Series was built with a heavier weld at the side sheet to side plate joints and with diagonal side braces designed to eliminate stress raisers.

Impact Tests—Seventy-five impact tests, forty-seven of which involved forces of 500,000 to 947,000 lb and speeds of 5 to 15.4 mph, showed that welded aluminum railway cars can be designed to stand up as well as steel cars under dynamic loading.

These tests were planned collisions between R.&S. car No. 1304 with a welded aluminum body and steel underframe and an all-aluminum covered hopper car with an A.A.R. type of welded aluminum centre sill.

The cars were loaded and during the tests the "on the rail" weight of the aluminum open hopper car was 200,000 lb and of the covered hopper car, 168,000 lb.

Electrical resistance SR-4 strain gauges, Type A5-1, were located on the covered hopper car to determine the stresses at various locations along the centre sill and in the body-to-sill connections, as well as to determine the distribution of force from the centre sill to car body. The impact force was determined by a dynamometer which replaced the coupling on the covered hopper car. The dynamometer was calibrated statically in compression in a Universal testing machine to determine the sensitivity. Deflection measurements were taken after each impact test to determine the amount of residual deformation in the cars. Piano wires were used as reference lines and deflections were obtained by measuring the distance between the wire and the car body, or centre sill.

The body of the car R.&S. 1304 suffered no significant damage throughout the seventy-five tests. At the conclusion of the tests there was visible deflection on the side sheets caused by the sand being forced into the front end of the car by the impacts, which were all in the same direction. When the sand was removed the deflection disappeared, which proved that it was elastic and not significant.

Two of the four diagonal side braces joining the car sides to the hopper peaks failed because of the shifting of the load during the tests. Two tie rods were used to counterbalance the forces exerted by the timber after the diagonal side braces had failed.

The tests were stopped after a force of 947,000 lb was reached because of the failure of the draft gears and steel draft lugs in the covered hopper car.

The data obtained have shown that the welded aluminum centre sill under dynamic loading meets the suggested requirements of the Association of American Railroads. Also, that the body and the body to centre sill connections on R.&S. car No. 1304 were adequate.

Economic Considerations—Operations of the R. & S.

In an attempt to evaluate the savings directly attributable to the use of aluminum cars, a careful analysis of its operating conditions has been made by the R.&S.

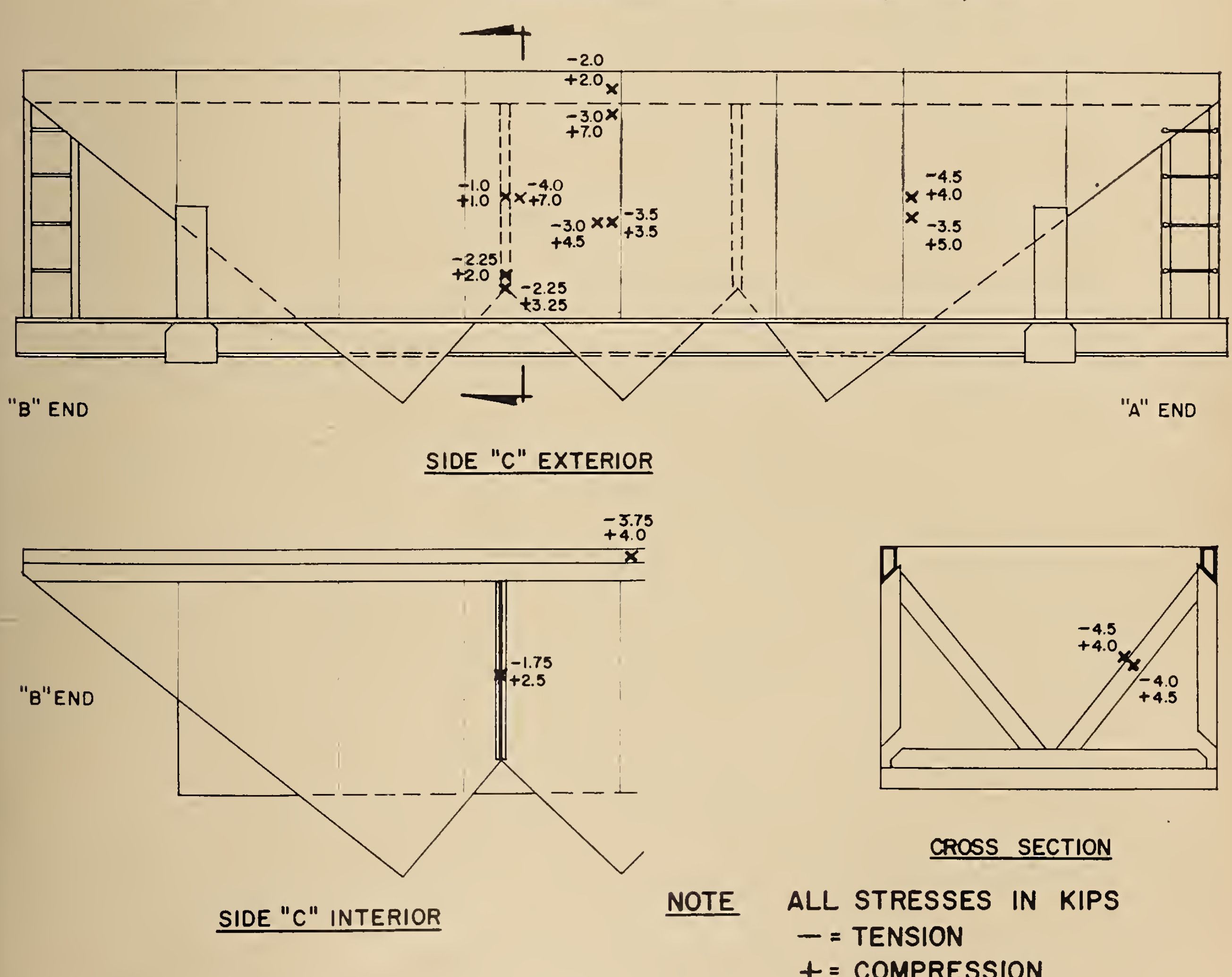
About 50% of the overall R.&S. operations and 90% of the open hopper car movement consist in moving bauxite from Port Alfred, P.Q., to the plant of the Aluminum Company of Canada, Limited at Arvida, P.Q.; the balance comprises carrying paper, coal and other commodities. In this operation, 213 open hopper cars are used, 148 of which are aluminum cars with 70-ton nominal capacity. Among the balance, which are steel cars, 19 are 70-ton cars with a light weight of 48,000 lb and 46 are 50-ton steel cars with a light weight of 39,000 lb.

The tonnage of bauxite moved on the R.&S. is in the order of 2 million tons per year. The bauxite is mined from large deposits in British Guiana and French West Africa, shipped to Port Alfred and unloaded at the dock either into R.&S. open hopper cars or large storage sheds.

During the navigation season, the R.&S. hopper cars are operated for 200 days with the average quantity of bauxite moved per day about 9000 tons, although on peak days it may go over 18,000 tons. During this period the cars may be loaded directly from the ship or from the warehouses. On the days of heavy traffic the cars are loaded and unloaded three times every two days. In the closed season of navigation, the cars are operated for about 100 days and carry about 4000 tons per day. The 40° slope cars are used and supplemented when necessary by the 30° slope aluminum cars.

Port Alfred is at sea level and the elevation at Arvida is 400 ft. above sea level. This change in elevation takes place within the first seven miles out of Port Alfred in the twenty miles of rail line. The ruling grade of 1.3% is continuous for this seven miles. The power used to make this haul is provided by 1600 hp diesel electric units operated singly or in multiple according to traffic conditions, with each unit capable of hauling about 1100 trailing tons up the grade. The average load in aluminum cars is about 80 tons, in 70-ton capacity steel cars about 70 tons and in 50-ton capacity steel cars about 50 tons. The 1100 trailing tons can be made up using mixed cars or with steel cars or aluminum cars loaded with bauxite. It is possible to haul eleven 70-ton capacity steel cars with about 1034 tons total trailing load, of which 770 tons are payload. Alternatively, it is possible to haul eleven

Fig. 5. R & S Hopper Car No. 1304. Peak Stresses During Shake-out Fatigue Test, Side "D"



aluminum cars which will give about 1056 tons trailing load, of which 880 tons are payload. Both operations are carried out with the same power, crew time and fuel consumption.

On the basis of its 2 million-ton operation, the R.&S. requires 28,570 carloads if the bauxite is carried in standard steel cars, or the proportionately reduced figure of 25,000 carloads if carried in aluminum cars, i.e., 2600 train loads in steel cars, or 2270 train loads in aluminum cars. Thus, if all trains consist of aluminum cars, a saving of 330 train loads is effected in moving 2 million tons.

The running time from Port Alfred to Arvida with a loaded train is about one hour, two hours are required to switch the empty and loaded cars and make up and dispose of the train, and another hour is needed to run from Arvida to Port Alfred to complete the cycle.

Saving In Time

The saving in time, if only aluminum 40° slope cars were used, would amount to about 1320 hr. of locomotive and crew time per year. A further saving in time is realized from increased efficiency in unloading aluminum cars with optimum slope. In unloading at Arvida a Hewitt-Robins Shaker is used in conjunction with compressed air jets. A thorough check of unloading operations disclosed that two 40° slope cars could be unloaded during the time required for one car with 30° slope sheets. The aluminum cars with 40° slopes discharge 80 tons during the time steel cars with 40° slopes discharge 70 tons. The 40° slope aluminum cars actually discharge bauxite under favourable conditions in one-eighth to one-tenth less time than that required for 30° slope cars.

Saving In Number

The saving in number of cars by 13 to 14% is reflected in labor costs for maintenance. Since the superior resistance of aluminum to corrosion has been amply demonstrated, the aluminum cars have never been painted. To date there has been no maintenance of any kind on the bodies of the 40° slope aluminum cars built in 1955 or of those built in 1957. Yet another saving of some proportions is in trackage for sidings; the decrease in the number of cars has brought about a decrease in the total length of yard tracks.

Conclusions

The experience with hopper cars on The Roberval and Saguenay Railway has established many interesting features:

1. The design of hopper car bodies can be simplified with a reduction in the number of shapes required;

2. The new concept in car design has simplified car shop practices in the construction of hopper cars;

3. Aluminum hopper cars provide a high degree of corrosion resistance and a high payload to deadload ratio;

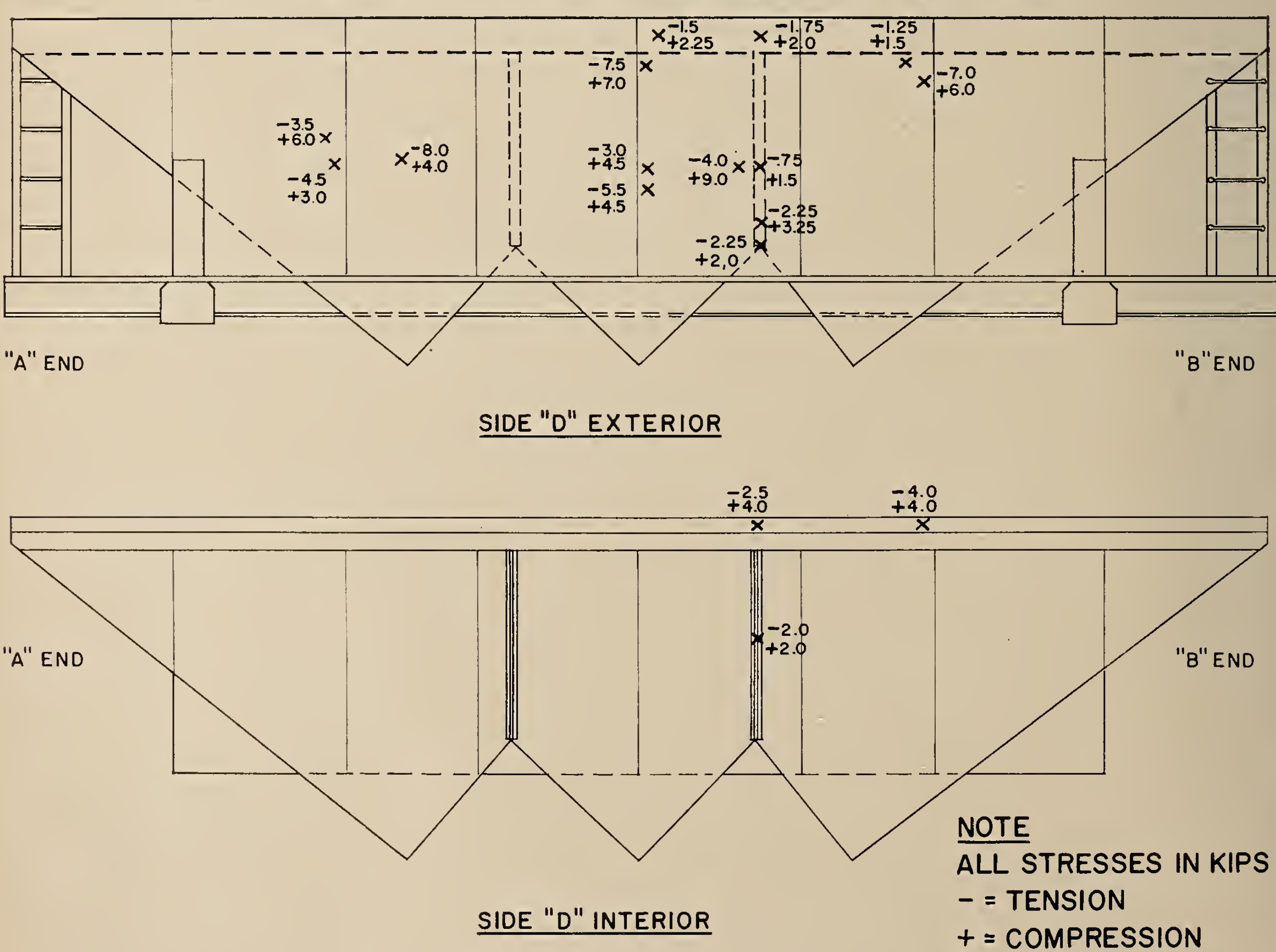
4. The development of aluminum alloys and high-speed welding overcame many of the advantages that steel construction had over aluminum in car shop practices;

5. Extensive tests demonstrated that welded aluminum structures can be designed to stand up as well as steel under dynamic loading;

6. Special cars for specific jobs can result in marked economies, particularly if the cars are operated in a closed circuit;

7. Light weight cars when used in ore service reduce the number of train loads moved per year.

Fig. 6. R & S Hopper Car No. 1304. Peak Stresses During Shake-out Fatigue Test, Side "C"



NUCLEAR RESEARCH REACTOR OPERATIONS

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BEFORE REFERRING TO problems associated with the operation of nuclear research reactors and illustrating the engineering uses to which these reactors are put at Chalk River, it is perhaps advisable to review briefly how a nuclear reactor works.

A nuclear reactor is basically a device which enables a fission chain reaction to proceed at a controlled rate with a means provided for removing the heat generated in the reaction. The fission process is initiated by a small particle called a neutron. Atoms of nearly all the elements contain neutrons in their nucleii. However, only a very few of the heavy elements, such as uranium, are fissile (capable of undergoing fission). Natural uranium contains 0.7% of uranium 235, the fissile isotope. When a neutron strikes a uranium 235 atom it can cause this atom to break into two fission fragments. Simultaneously, two or more neutrons are liberated and a large amount of energy is released. The energy appears in the form of heat. The neutrons produced are travelling quite fast. They must be slowed down before they will initiate fission in other uranium 235 atoms. The material used to slow down the fast neutrons is called a moderator. Graphite and heavy water are the most common moderators. Of the two, heavy water is by far the most effective. Once slowed down, the two neutrons liberated during fission will cause other uranium 235 atoms to split or fission. This, in turn, results in the production of four neutrons and the cycle is repeated for each of these. This is how the fission chain reaction is propagated.

In a reactor the fuel containing the fissile uranium, and the moderator are so arranged that more neutrons are produced than are lost to the structure. To ensure neutron economy the reacting core is usually surrounded with a reflector to divert escaping neutrons back into the chain reaction. Control of the reaction is usually achieved by insertion of strong neutron absorbers, such as boron or cadmium rods, into the core. The reactor power may also be controlled by varying the moderator level in the reactor vessel if heavy water is used as the moderator. This method of control adjusts the quantity of fuel in the reacting mass. In many reactors both methods are used to control the reaction. If the number of neutrons absorbed in the core exceeds those produced, the reactor is said to be sub-critical. When these two quantities are equal the reactor is just critical. The condition when more neutrons are produced than lost is termed over-critical. This latter state is required to achieve a self-sustaining chain reaction. If the reaction were left unchecked, the reactor structure would eventually melt due to the heat produced. Thus a coolant must be provided to remove the heat generated in the fuel. In research reactors the heat removed is generally put to no useful purpose, whereas in power reactors it is used to produce steam which in turn operates a turbine to produce electricity. The prime purpose of a research reactor is to produce an abundant supply of neutrons for experimental purposes.

There are five research reactors at the Chalk River Project operated by Atomic Energy of Canada Limited. Four are in operation and one is under construction. The two principal reactors are NRX which has been in operation since 1947 and NRU which was commissioned in 1957. Both of these reactors are natural uranium fuelled and heavy water moderated. I will now briefly outline the main features of these reactors.

A photograph of the NRX reactor model is shown in fig. 1. The reacting vessel is fabricated of aluminum and is essentially a tank 10 ft. in diameter by 10 ft. high. The tank is penetrated with approximately 200 tubes into which the natural uranium fuel rods are inserted. Heat is removed from the fuel by means of water from the Ottawa River which enters at the top and leaves at the bottom. The effluent coolant is passed through delay tanks prior to discharge to the river. The heavy water moderator system is totally enclosed in stainless steel pipe and storage tanks vented with helium gas. Provision is made for introducing moderator to the reactor vessel and for cooling it in heat exchangers to remove the heat generated in the reaction. Water cooled steel and aluminum thermal shields are located above and below the vessel to remove the heat created by the intense gamma radiation. An air-cooled graphite reflector surrounds the vessel to divert back into the reacting core neutrons that would otherwise be lost to the reaction. The maximum reactor power is 40,000 KW. Fuel changes must be made with the reactor shut down. Following withdrawal of the spent fuel into a flask shielded with 10 in. of lead, the fuel is discharged to a water-filled trench or canal for storage.

A photograph of the NRU reactor model is shown in fig. 2. The reacting vessel is made of aluminum and stainless steel. Unlike NRX there are no tubes in this vessel. The fuel elements are inserted directly into the moderator in the tank. Provision is made for 227 fuel rods. The natural uranium fuel in this case is cooled by the heavy water system. The combined moderator-coolant is contained in a closed stainless steel piping system and is circulated continuously through heat exchangers to remove the heat produced in the fuel. The present reactor power is 200,000 KW, five times that of NRX, and the fuel may be changed with the reactor operating. Fuel removal is accomplished in a manner somewhat similar to that employed in NRX, except that the removal flask also provides heavy water cooling.

Although both reactors are fuelled with natural uranium, the geometrical arrangement of the two fuel elements is quite different. This is primarily due to the higher power of the NRU reactor. The fuel in the NRX reactor takes the shape of solid uranium cylinders clad with aluminum. This clad prevents corrosion of the fuel by the coolant and serves to contain the fission products. Fig. 3 indicates a schematic diagram of the NRX fuel element. The clad uranium bar is inserted into an aluminum can to provide a channel for coolant flow. This passage is made quite small in the interests of neutron economy to reduce the number of neutrons captured by the coolant.

The NRU fuel element is shown in fig. 4. Owing to the high power of NRU, more heat must be removed from each fuel element than in NRX. The heat transfer rate in the NRU fuel may be as high as 600,000 BTU/hr./sq.ft./°F. One shape that satisfies this condition comprises five uranium flats clad with aluminum. The flats are placed inside an aluminum can which acts as a flow director for the moderator coolant. From a nuclear standpoint this fuel element achieves better neutron economy than that in NRX, as the heavy water coolant does not absorb as many neutrons as ordinary water.

Now that we have seen how we make nuclear reactors work and have a general idea of the construction of the NRX and NRU research reactors at Chalk River, I would like to discuss one of the major problems encountered in reactor operation. This is concerned with the continuous removal of heat generated in the fission chain reaction. The heart of a nuclear reactor is the region containing the fuel. It is here that the heat is initially generated and transferred to the coolant. Specifically, I will refer to heat removal from the reactor fuel, although there are many other auxiliary cooling circuits in a reactor system to which many of the remarks to follow also apply.

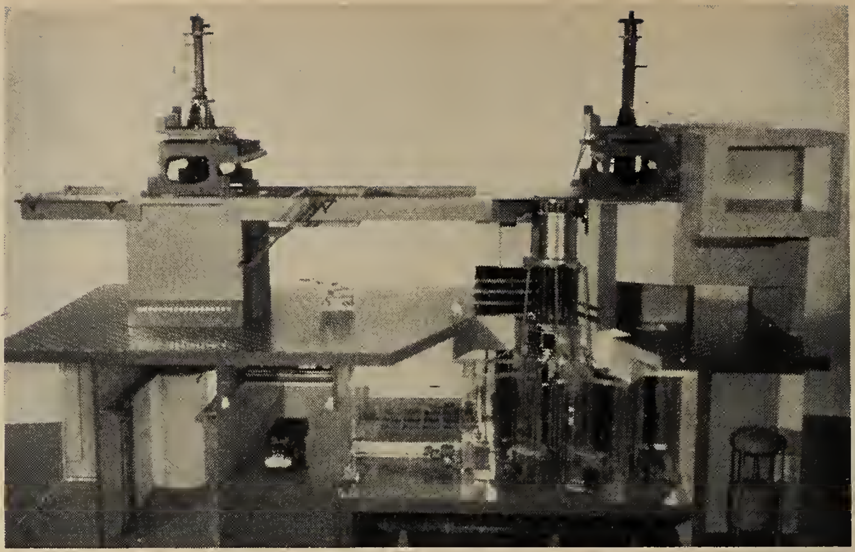

Fig. 2. Model of the N.R.U. Reactor

The NRX fuel element is cooled with Ottawa River water. The coolant passage is made as small as possible consistent with adequate heat transfer for reasons mentioned previously. Uranium metal tends to distort after it has been in the reactor for a while. This usually results in an overall length change together with expansion of the diameter. This may lead to partial blockage of the coolant channel and in some cases complete blockage. The effluent coolant stream is so instrumented that a reactor shutdown is called for when the coolant on an individual element is not adequate. Complete and rapid shutdown is mandatory in this condition. Otherwise the fuel would overheat, culminating in a meltdown of the element with possible damage to the reactor vessel tube. In addition, radioactive fission products might enter the water coolant, the air coolant in the annulus between the vessel tube and the fuel element, and the moderator. For fission products to escape from the fuel, it is assumed that one or all of the following components will have ruptured: the fuel clad, the coolant containment can, and the vessel tube.

Fig. 1. Model of the N.R.X. Reactor

A review of operating experience with the NRX reactor shows that incidents of this nature have in fact occurred. For example, in 1952 a power surge occurred during an experiment to determine reactor behaviour. This resulted in severe damage to several fuel elements and the reactor vessel. The coolant flows on several fuel rods were reduced for the experiment. The coolant boiled out of these rods as the reactor power increased and this loss of coolant resulted in a further power rise. The fuel temperature increased until it melted and the fuel cladding, the coolant can and the vessel tubes in these positions ruptured. The coolant mixed with the heavy water moderator. Fission products were released to the water coolant leaking from the damaged rods and also to the air coolant exhaust. Owing to a combination of errors the reactor control system did not stop the reaction before this damage was done. If personnel and equipment had functioned normally this accident might never have happened. Fourteen months elapsed before repairs were completed and the reactor was back in operation.

Following the accident the control system came under close scrutiny with a view to improving the reliability. This event showed clearly that the prime shutdown devices viz. the boron carbide neutron absorbers, called shut-off rods, were not reliable. These devices were normally held out of the reactor during operation. However, they are poised above the core, ready to drive into the reactor and stop the chain reaction when a condition hazardous to continued operation develops. In 1952 these rods were pneumatically operated in travelling in and out of the reactor core. Their performance had not been without failure due to the close tolerances required for air operation. In 1955, this air driven shut-off rod was replaced with a type using a motor driven cable hoist. This new type of shut-off rod has performed very well. To date these rods have never failed to shut down the reactor when required. In addition, the shutdown capacity of the control system has been augmented by the requirement of a moderator dump from the reactor vessel on every shutdown.

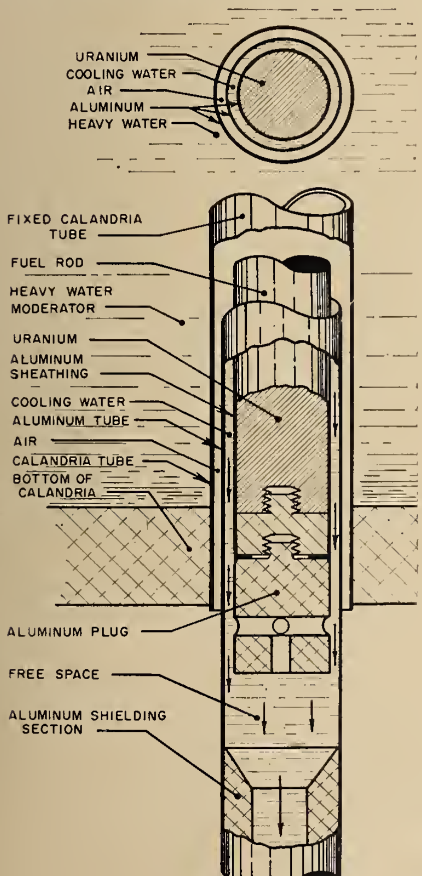

Fig. 3. Schematic Diagram of NRX Fuel Rod in Calandria Tube

Operating experience indicates that we now have a very reliable shutdown system in NRX that will function properly when required e.g. when coolant flow to a fuel element is not adequate.

The instrumentation used to monitor the fuel coolant flow was triplicated recently to improve its reliability. The electrical circuits used to shut down the reactor are so arranged that two of the three instruments must see the unsafe condition to initiate an automatic reactor shutdown. The latter is referred to as a reactor trip and the associated electrical circuits are termed trip circuits. This type of system has practically eliminated transient trips due to instrument failure. This is reflected in increased reactor operating efficiency. The triplicated system also permits testing of individual trip circuits and instruments with the reactor operating, as one circuit out of operation does not call for a reactor trip. The fuel rod coolant monitoring system has been used as an example of how multiplication of instrumentation will provide safer, more reliable protection. Triplication of instrumentation has been applied to all important systems used to detect unsafe reactor conditions.

If natural uranium fuel could be so fabricated that it did not distort under irradiation then the coolant flow would remain unchanged throughout the lifetime of the rod in the reactor. It does not appear practical to make such a fuel rod. However, continued efforts are being made to fabricate fuel that will exhibit a minimum distortion when irradiated in a reactor.

In summation then, with regard to the heat removal problem, it is essential that reliable instrumentation be provided to sense the unsafe coolant condition and that reactor shutdown be initiated immediately by reliable shutdown devices on a signal from these instruments.

Many of the problems encountered in reactor operation are due to the presence of radioactivity. A nuclear reactor generates various types of radiation which are biologically dangerous. Shielding must be provided to reduce the radiation to safe working levels for personnel. In addition, all personnel working at a reactor site are provided with film badges and pencil dosimeters to measure their radiation exposure. Records of individual exposure must be carefully maintained to ensure that no one exceeds the permissible amount of radiation on a weekly, quarterly, and yearly basis.

If we consider the reactor structure, we see that many feet of concrete

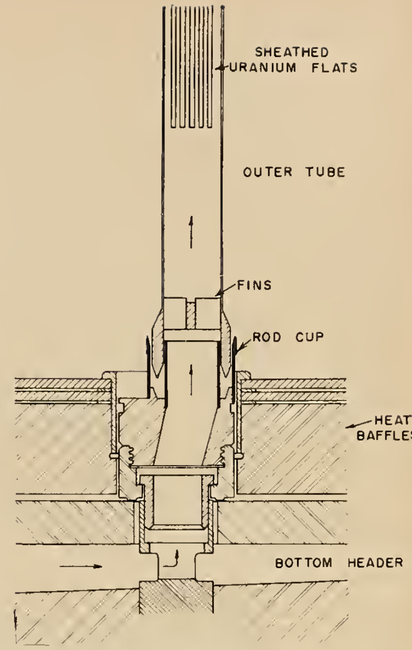

Fig. 4. NRU Fuel Rod and Cup Assembly

shielding have been provided to protect personnel from irradiation. No one could work around the face of the reactor if this shield were not present. This protection is, of course, augmented by routine radiation surveys taken around the reactor. Particular attention is given to horizontal penetrations in the biological (concrete) shielding used for experimental purposes.

It is also readily apparent that any material removed from the reactor core will be highly radioactive. This requires the use of shielded removal containers and special operating procedures. Let us consider the case of removal of a ruptured fuel element from the NRX reactor. This assumes that the aluminum clad has ruptured and fission products are present in the coolant stream. A flask shielded with 10 inches of lead is used to contain the fuel as it is withdrawn from the reactor. Temporary cooling must be applied to the rod during its extraction due to the residual heat contained therein. Water spilled during changing of coolant connections will be radioactive due to the fission products it contains. This may give rise to airborne contamination in the reactor building. If this should occur, personnel working on the fuel removal will be required to wear respirators or perhaps fresh air masks. These will provide protection against internal contamination. Also to control the spread of contamination, an area local to the fuel removal operations is generally isolated from the rest of the building. This avoids contamination spreading on the feet of the workers. Personnel monitoring stations located in these areas must be used before leaving them. Fuel removal requires men to work in a room below the reactor to disconnect the coolant connections. These workers are provided with a complete change of clothing including a plastic suit, hood, and fresh air mask. Communication is provided by a microphone installed in the mask connected to a public address system. In addition, warning of high radiation levels in operating areas is provided by instruments which sound a distinctive signal.

Once the fuel is removed it is transferred in the shielded flask to a canal system. Here, radiation protection is provided by a shield of 12 ft. of water. This permits workers to cut and handle the irradiated fuel with special tools where they can see what they are doing.

The presence of radioactivity can make even the simplest maintenance job a complicated operation. When maintenance of equipment is required, radiation surveys and protective clothing are provided much in the same manner as described for fuel removal. On some occasions when the radiation level is high, temporary shielding must be installed to reduce the radiation to safe working levels. In situations where the radiation level may change abruptly, a radiation surveyor is constantly in attendance to monitor the health hazard. Accessibility of equipment in reactor systems is essential if reasonably fast, effective maintenance is to be carried out. Equipment that is essential to the continued operation of the reactor is generally provided in duplicate. One of the units acts as standby in the event of failure of the other. This means that maintenance of the failed unit can be deferred to a scheduled shutdown and reactor operation can continue with only a minor interruption.

Waste disposal is another problem created by the dangerous radiation generated within a reactor. Liquid wastes having low radiation levels are pumped to large disposal pits located within the confines of the project. Here the liquid seeps through the sandy soil which retains the radioactivity. Movement of this activity in the soil is carefully surveyed on a continuing basis. High radiation liquid wastes are concentrated and stored in stainless steel tanks underground. Solid wastes are buried in the ground in a specially designated disposal area. Some material is buried directly in the soil; some is placed in steel and concrete containers installed in the ground. These containers are sealed with asphalt when filled.

The air coolant from the reactors is passed through absolute filters to remove active particulate material before it is discharged to the atmosphere through a 200 ft. stack. The single pass of water used to cool the NRX fuel is directed through two tanks in series to delay it before it is ultimately discharged to the Ottawa River. In the tank the radiation contained in the coolant decays to levels well below permissible drinking water tolerance.

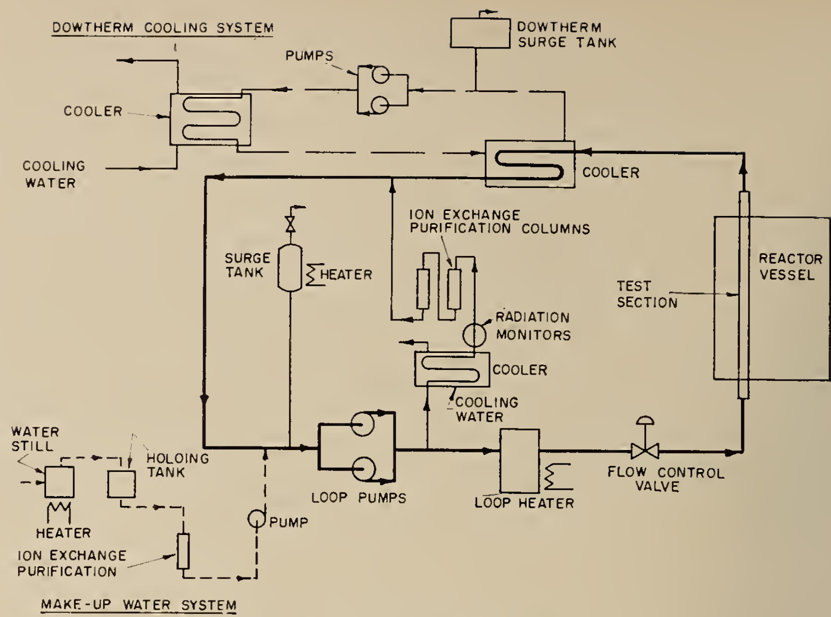

Fig. 5. Loop Schematic Diagram

The reactors at Chalk River are used for a great variety of experiments. The most important engineering use to which the reactors are put concerns the testing of prototype fuel elements and materials for use in power reactors. Facilities are installed in the reactors which provide the sort of environment to be found in nuclear power reactors. A typical facility is shown schematically in fig. 5. This comprises a closed piping loop which allows the circulation of water at a pressure of 2,000 p.s.i. and a temperature of 600°F. Fuel elements are inserted in the pressure tubes which are located in the reactor core. Cooling is provided by the pressurized water. Six of these so called "loops" are in operation in NRX and two in NRU. Uranium oxide fuel is undergoing rigorous tests in these facilities as this is the type planned for the NPD-2 reactor, Canada's first power demonstration project, and also for the CANDU reactor, the 200 MW power station now being designed. The cladding material being tested for use with the oxide fuel is an alloy of zirconium metal called Zircaloy-2. The latter has mechanical properties which permit its use under power reactor conditions. Further, it is suitable from a nuclear standpoint in that it has a low affinity for neutrons.

The pressure tubes for these loops are installed in the reactor vessel tubes replacing standard fuel elements. The operation of the loops is of necessity closely integrated with that of the reactor. Instrumentation on the loops is used to sense conditions which are hazardous for the operation of the experiment as well as for reactor operation. In the latter case a trip signal is sent to the reactor control room to initiate automatic shutdown.

The NRX reactor has proved to be a most valuable and versatile research machine during its 12 years of operation. It is indeed a credit to the original designers. Much information has already been provided to the power reactor designer through data obtained in NRX experiments. More data will be forthcoming from experiments now in progress. The NRX reactor has kept pace with the times. The latest developments are incorporated in its control and safety systems. Fuel element designs for the NRU reactor and for submarine propulsion reactors were tested in its core. Fuel designs for Canada's first nuclear power reactors are now being tested in NRX. Now that NRU has been successfully operated for about two years, this reactor is sharing the experimental load with NRX. Designed as a plutonium producer as well as for engineering testing, the NRU reactor has already produced outstanding experimental work. The operation of these two reactors has contributed to a very large extent to the advancement of nuclear reactor technology and will, I am sure, continue to do so in the future.

INTERPRETATION OF RHEOLOGICAL DATA FOR ENGINEERING USE

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Increasing applications of the flow of complex mixtures such as solid-liquid suspensions, high pour point crude oil and other non-Newtonian materials require of the engineer some appreciation of the elements of rheology and the interpretation of laboratory measurements of consistency.

The basic rheological classifications are defined and reviewed. The versatile rotational viscometer is described and its calibration and use for the testing of non-Newtonians is outlined. A method of data interpretation for engineering use is presented. The method permits a ready visualization and assessment of the extent and kind of non-Newtonian behaviour over a wide range of shear rate.

Introduction

THERE IS INCREASING interest in the flow and related behaviour of complex mixtures and especially of solid-liquid suspensions. Recent developments and full scale application of the pipeline transport of suspended solids have called for a knowledge of the consistency or "viscosity" of such mixtures. Applications of "heavy media" to mineral ore processing and of suspended solids systems as heat transfer media also require an appreciation of the effect of concentration and other variables upon consistency. The so-called "high pour point" crude oils are non-Newtonian and exhibit unusual flow behaviour at moderately low temperatures. The engineer who is not a specialist in rheology generally considers the property of viscosity to be the one and only measure of consistency and often is at a loss to interpret basic rheological data obtained in the laboratory. Yet such a knowledge is vital to an understanding of the flow behaviour of these mixtures and plays an important role in their heat and mass transfer characteristics. This review is written to acquaint the non-rheologist with a few of the basic concepts of rheology, with the calibration and use of the versatile rotational viscometer and with a method of data interpretation which the author has found useful in engineering application of rheological data.

Rheological Classification of Fluids

Many discussions of the rheological classification of fluids have appeared in the recent literature. The following brief discussion is taken from a previous paper.[2]

Fluids are classified into several rheological types in accordance with their behaviour when subjected to shearing forces of such a magnitude as to cause laminar or non-turbulent motion of the fluid. Conventionally, the unit shearing stress, (dF/dA), is compared with the rate of shear or the velocity gradient developed normal to the applied stress, (dV/dX). Typical shearing stress—rate of shear curves appear in Fig. 1 (arithmetic coordinates) and Fig. 2 (logarithmic coordinates). These figures have been prepared for fluids behaving similarly at one rate of shear and illustrate their different behaviour at other rates of shear.

In the case of most liquids and all gases the rate of shear developed is found to be directly proportional to the unit shearing stress applied. This may be stated by the simple relationship

$$\frac{dF}{dA} = \frac{\mu}{g_c}\frac{dV}{dX} \qquad (1)$$

where

(dF/dA) is the unit shearing stress, or the shearing force per unit area,

(dV/dX) is the velocity gradient normal to the applied shear, or the rate of shear,

μ is the constant of proportionality known as the viscosity,

g_c dimensional conversion factor.

A fluid whose rheological behaviour is described by equation (1) is known as a Newtonian fluid, and a single quantity, the viscosity, serves to give a complete description of its rheological behaviour. This relationship for a typical Newtonian fluid is shown by the line so labelled in Figs. 1 and 2. Inasmuch as viscosity itself is defined by equation (1) it is clear that only a fluid which behaves in accordance with this equation can be considered to exhibit the property of viscosity. Interpretation of the Newtonian line on Fig. 1 indicates that the viscosity of a Newtonian fluid is the slope of the line when the unit shearing stress is plotted against the rate of shear on arithmetic coordinates. Since for Newtonian fluids this line is necessarily a straight line through the origin, the slope is constant and the viscosity is independent of the rate of shear. On logarithmic coordinates the Newtonian fluid exhibits a straight line of slope equal to one—see Fig. 2.

Certain fluids, notably those of complex compositions or those which are really physical mixtures, do not exhibit this simple relationship when the unit shearing stress is plotted against the rate of shear. These fluids are called non-Newtonian. Some such systems yield a complex shearing stress—rate of shear curve which cannot simply be described. Among the simpler cases, however, are the Bingham plastic and the pseudo-plastic. The Bingham plastic is defined as a material for which a finite shearing stress is required to initiate shear and for which there is a linear relationship between all greater unit shearing stresses and rate of shear. The Bingham plastic is defined mathematically by equation (2):

$$\frac{dF}{dA} - \tau_y = \frac{\eta}{g_c}\frac{dV}{dX} \qquad (2)$$

where

τ_y is the yield of the material corresponding to the unit shearing stress

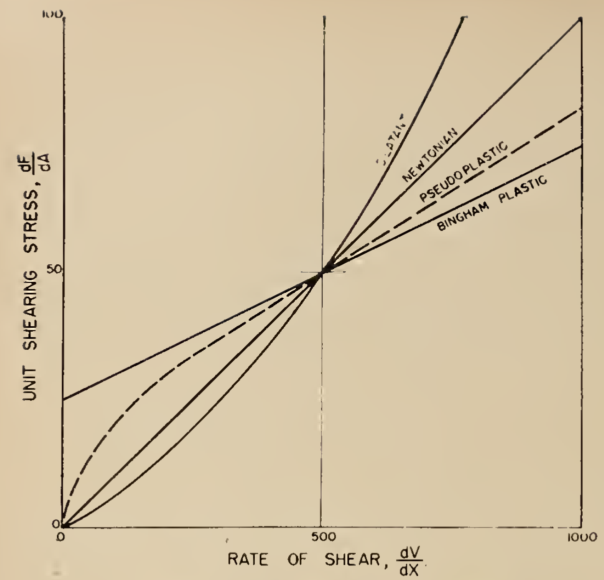


Fig. 1. Unit Shearing Stress—Rate of Shear Relationships (Arithmetic Plot).

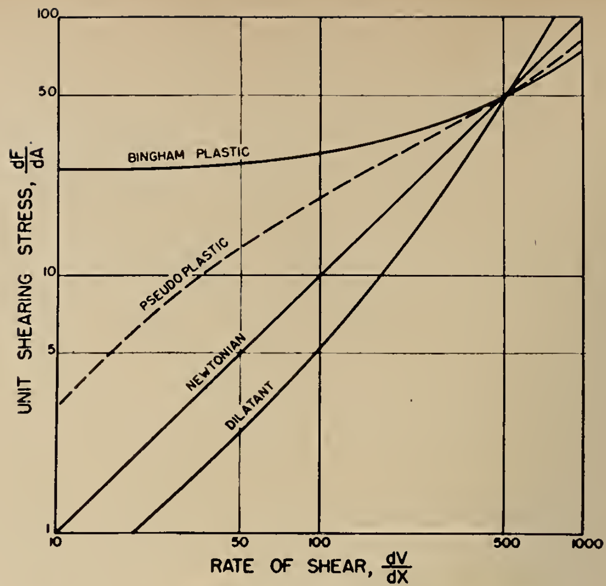


Fig. 2. Unit Shearing Stress—Rate of Shear Relationships (Logarithmic Plot).

required to initiate motion

η is the coefficient of rigidity.

The relationship between unit shearing stress and rate of shear for a Bingham plastic is indicated by the line so labelled in Figs. 1 and 2. The intercept on the unit shearing stress axis on Fig. 1 corresponds with the yield value, τ_y, and the slope of the straight line is the coefficient of rigidity, η. On logarithmic coordinates (Fig. 2) the Bingham plastic exhibits a curve convex to the rate of shear axis approaching zero slope at low shear rates and a slope of one at high shear rates. Relatively few materials have been found to exhibit true Bingham plastic behaviour and this rheological type is important chiefly in that it serves as a limiting case for the pseudo-plastic type.

A pseudo-plastic material may best be defined by reference to the line labelled pseudo-plastic in Fig. 1. On arithmetic coordinates the line relating the unit shearing stress to the rate of shear passes through the origin and is curved convex to the shearing stress axis up to a certain shearing stress, but is approximately linear with rate of shear beyond that point. On logarithmic coordinates (Fig. 2) the pseudo-plastic yields a relationship similar to that of the Bingham except at low rates of shear. It will be apparent that at high rates of shear pseudo-plastics behave much like Bingham plastics in that there is a near linear relationship between the shearing stress and the rate of shear. Because of this, pseudo-plastics are occasionally characterized, at high rates of shear, by an "apparent coefficient of rigidity" and an "apparent yield value". The apparent coefficient of rigidity is equal to the slope of the near linear part of the curve on the arithmetic coordinates and the apparent yield value is equal to the intercept formed by linear extrapolation of the line to zero rate of shear.

Among several other types of non-Newtonians is the dilatant fluid whose characteristics are indicated by the line labelled dilatant in Figs. 1 and 2. This type of fluid is less commonly encountered.

The widespread use of the term "viscosity" as a measure of consistency has led to its incorrect use in the case of Bingham plastics, pseudo-plastics, dilatant fluids, and other rheological types. Since the viscosity of a Newtonian fluid is proportional to the ratio between the unit shearing stress and the rate of shear, the term viscosity has been applied to this same ratio in the case of non-Newtonians. It is clear from Fig. 1, however, that the ratio between unit shearing stress and the rate of shear for Bingham plastics, pseudo-plastics, etc., varies at different rates of shear indicating different consistencies. These different consistencies should not be referred to as viscosities, but may usefully and accurately be called "apparent viscosities".

Thus while the Newtonian fluid is rheologically characterized by a single quantity, the viscosity, which is independent of the rate of shear; the Bingham plastic and other rheological types are sufficiently complex to require more than one quantity to define the shear stress-rate of shear curve and to describe their rheological behaviour. Alternately, the rheological properties of these latter materials may be described by a series of apparent viscosities spanning the range of rates of shear of interest. This latter method has found favor among engineers because of the similarity of meaning and the identity of units and dimensions of apparent viscosity and viscosity.

Rotational Viscometer and Calibration

Many different types of viscometers have been developed for the testing of both Newtonian and non-Newtonian fluids. These are discussed in detail elsewhere[6]. Of all the types the concentric cylinder instrument is probably the simplest of the designs really useful for the study of non-Newtonians. This instrument, of which there are many varieties on the market, consists essentially of an inner and an outer cylinder so arranged that, with the fluid to be tested in the annular space between the cylinders, one of the cylinders may be rotated while the torque transmitted through the fluid to the other stationary cylinder is measured in some way. A popular semi-precision commercial viscometer of this type is the Model 35 manufactured by the Fann Instrument Corporation, Houston, Texas. The Fann instrument combines simplicity of operation with good accuracy and permits sustained testing at each of several rates of shear.

For use with a Newtonian liquid the relationship between the rate of shear at the stator wall and the rotor speed for such a rotational viscometer may be determined mathematically from the Reiner-Riwlin[8] equation which is

$$\frac{dV}{dX_r} = \frac{4\pi R_1^2 R_2^2}{r^2(R_2^2 - R_1^2)} N \qquad (3)$$

where

(dV/dX) = rate of shear, sec^{-1} at the stator wall

R_1 = inner radius of the annulus

R_2 = outer radius of the annulus

s = ratio of the outer to the inner radius of the annulus = (R_2/R_1)

r = radial position at which

shear rate is given when $R_1 < r < R_2$

N = rotor speed, rev. per sec.

If the outer cylinder is rotated and the torque on the inner cylinder is measured it is the rate of shear at the wall of the inner cylinder that is of interest.

Substituting R_1 for r,

$$\frac{dV}{dX_{R_1}} = \frac{4\pi}{1 - 1/s^2} N \qquad (4)$$

Conversely if the inner cylinder is rotated and the torque on the outer cylinder is measured the rate of shear at the wall of the outer cylinder is of interest and

$$\frac{dV}{dX_{R_2}} = \frac{4\pi}{s^2 - 1} N \qquad (5)$$

For the remainder of this discussion it will be assumed that, as in the Fann viscometer, the torque on the inner cylinder is measured. Accordingly equation (4) relates the rate of shear of interest to the system geometry and the rotational speed.

The relationship between the deflection of the spiral spring, or other torque measuring device, and the unit shearing force at the stator wall is best determined by calibration. This may be done readily by obtaining speed-deflection data for a true Newtonian liquid of accurately known viscosity. A linear relationship between deflection and unit shear stress may be assumed, viz.

$$\frac{dF}{dA_{R_1}} = K\theta \qquad (6)$$

where

$\frac{dF}{dA_{R_1}}$ = unit shear force in the liquid at the wall of the inner cylinder (stator), dynes per sq. cm.

θ = deflection of torque measuring device, degrees or divisions

K = factor of proportionality.

With measured values of N and θ, and the viscosity of the calibrating liquid, simple solution of equations (1), (4) and (6) will yield values of K. A well designed instrument will yield the same value of K for any Newtonian liquid at any operating speed, N, so long as laminar flow conditions prevail in the annulus. Maintenance of laminar flow may be checked by the modified Reynold's criterion of Barr[1]. As quoted by Merrill[5], this criterion indicates that stable laminar flow maintains to a value of the dimensionless quantity

$2\pi R_2(R_2 - R_1)\rho/\mu$ equal to 500.

In this expression ρ is the density of the fluid in the annulus.

Data Processing

Equations (4) or (5) and (6) or its counterpart for the outer cylinder constitute the calibration equations for a rotational viscometer for use with any Newtonian liquid. The Reiner-Riwlin equation (3), upon which equations (4) and (5) are based, is however strictly applicable only when the annular fluid is Newtonian. The more general Krieger-Maron[4] equation expresses the rate of shear at the stator wall for a non-Newtonian. This equation applied to the wall of the inner cylinder is

$$\frac{dV}{dX_{R_1}} = \frac{4\pi}{1 - 1/s^2} NF \qquad (7)$$

where

F = Krieger-Maron correction factor for non-Newtonian annular fluid

$$= 1 + k_1\left(\frac{1}{n''} - 1\right) + k_2\left[\left(\frac{1}{n''} - 1\right)^2 + \frac{d(1/n'' - 1)}{d \ln v}\right]$$

and

$$k_1 = \frac{s^2 - 1}{2s^2}\left(1 + \tfrac{2}{3} \ln s\right)$$

$$k_2 = \frac{s^2 - 1}{6s^2} \ln s$$

n' = slope of log-log plot of θ vs N.

Often the final term in the Krieger-Maron correction factor is relatively small and may be neglected.

Thus for use with a non-Newtonian fluid the basic equations for interpretation of data are equation (6) with the value of K determined with the aid of equation (1) from a Newtonian calibration, and equation (7) with the value of F determined from a log-log plot of θ versus N. Much data in the literature has been calculated using equation (4) instead of the recently developed equation (7). Fortunately in most cases the F factor is not too much greater than unity and the error is relatively small.

For ordinary applications in a thorough investigation of the rheological characteristics of a fluid, θ values should be determined over a wide range of rotor speeds corresponding to rates of shear from below 10 to about 1000 sec^{-1}. Determinations should be made at controlled temperature and must be made under laminar flow conditions. The raw $\theta - N$ data are conveniently plotted on multicycle log paper for preliminary smoothing and Krieger-Maron processing. Derived (dF/dA) and (dV/dX) data are also conveniently plotted on multicycle log paper from which the extent and kind of non-Newtonian behaviour is clearly apparent.

Data Interpretation

A technique found by the author to be extremely useful is to plot the final results as $(dF/dA) + 0.1$ versus $(dV/dX) + 0.1$ on 5 or more cycle logarithmic paper. The addition of the small constants permits the 0.1, 0.1 co-ordinates to serve as the origin of co-ordinates with respect to (dF/dA) and

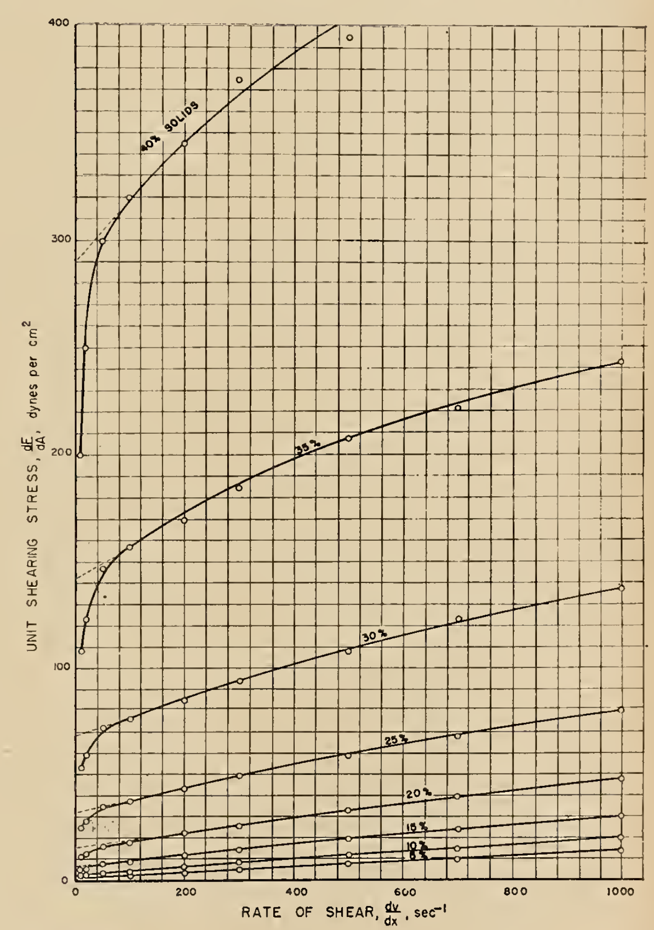


Fig. 3. Typical Unit Shearing Stress—Rate of Shear Data (Arithmetic Plot).

(dV/dX) themselves. In this way data may be extrapolated to the origin in the many cases where pseudoplastic behaviour is encountered. The utility of the plot is further enhanced by drawing in the lines corresponding with Newtonian fluids of 1, 10, 100, 1000 and 10,000 centpoise. Beyond the first two cycles of both coordinates these lines appear as straight lines of 45° slope and serve as a third scale from which one may read directly the viscosity, apparent viscosity, coefficient of rigidity or apparent coefficient of rigidity for a system for which test data are plotted.

If on such a plot the data form a curve which asymptotically approaches a horizontal line at low rates of shear and a 45° line at high rates of shear, Bingham plastic behaviour is indicated. The yield value, τ_y, may be read directly from the ordinate scale by extrapolating the horizontal portion of the curve and the coefficient of rigidity may be read directly from the position of the 45° line with respect to the "third scale". Moreover apparent viscosities at any rate of shear may be read directly from the intersection of the data point curve with the third scale lines of constant apparent viscosity.

More commonly the data for systems of engineering interest will form a curve indicating pseudo-plastic behaviour. Assuming such behaviour, one can extrapolate the curve to zero rate of shear using as a general guide the curves of the Newtonians. If necessary the data may also be extended to higher rates of shear by trending the curve asymptotically to a 45° straight line. From such an extended curve apparent viscosities may be read directly for any rates of shear of interest.

Frequently it is convenient to represent pseudo-plastics in an approximate manner by treating them as though they were Bingham plastics and assigning apparent yield values and apparent coefficients of rigidity to them. Such a procedure is often justifiable when the flow behaviour at relatively high rates of shear is of major interest. There are a variety of ways of obtaining these apparent properties. One way is from an arithmetic plot of the (dF/dA) – (dV/dX) data. Here the apparent yield value is obtained by linear extrapolation to zero rate of shear of the near-linear portion of the curve. The apparent coefficient of rigidity is obtained from the slope of the near-linear portion of the curve. Another method of obtaining the apparent coefficient of rigidity is to plot the ratio of (dF/dA) to (dV/dX) (which is the apparent viscosity) versus (dX/dV) and to extrapolate to zero (dX/dV) or infinite (dV/dX). This method is recommended by Weltmann.[9] A third way of obtaining the apparent properties is from a logarithmic plot either of (dF/dA) versus (dV/dX) or of

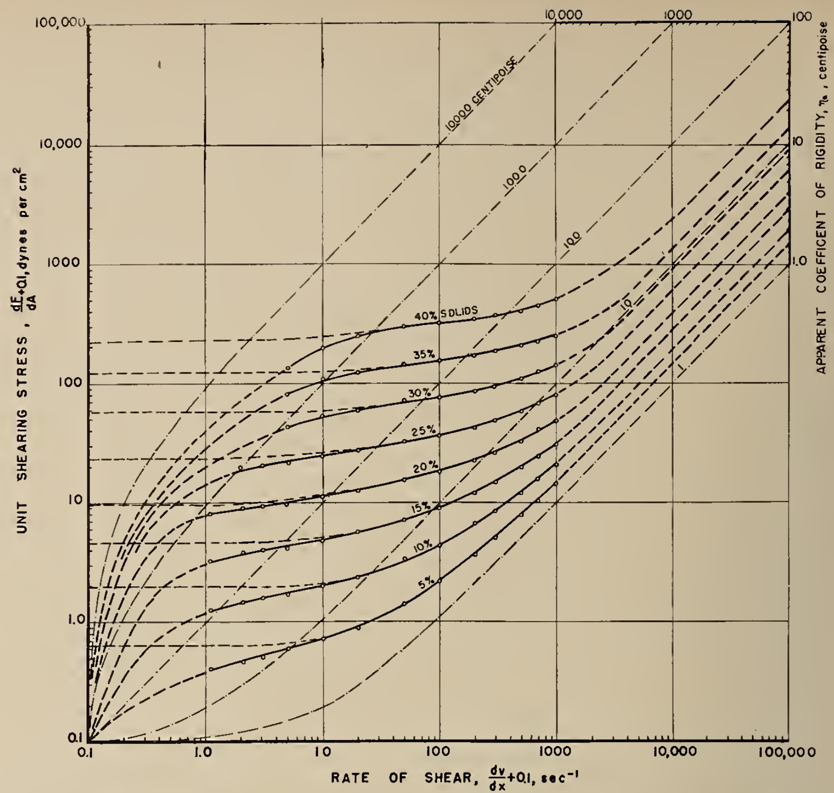


Fig. 4. Typical Unit Shearing Stress—Rate of Shear Data (Modified Logarithmic Plot).

$(dF/dA) + 0.1$ versus $(dV/dX) + 0.1$. In this case the apparent yield value is obtained by horizontal extrapolation of the experimental curve from the convex to concave inflection point. The apparent coefficient of rigidity is obtained by extrapolation of the high rate of shear portion of the curve asymptotically to the limiting 45° straight line.

None of these methods has any fundamental advantage over the others because the apparent properties have little fundamental significance in any case. The author uses all methods but rather favours the last mentioned especially when dealing with a family of curves for related mixtures.

To illustrate the methods of data interpretation, typical (dF/dA) and (dV/dX) data for a series of clay-water suspensions are given in Figs. 3 and 4, Fig. 3 is the conventional arithmetic plot of the data while Fig. 4 represents the same information on the modified logarithmic plot. Both figures indicate that all of the suspensions behave as pseudo-plastics but that at rates of shear above about 10 reciprocal seconds their behaviour approaches that of Bingham plastics. Fig. 4 permits ready extrapolation of the data to zero and to high rates of sheer. Thus the heavy curves through the data points and the heavy broken line extensions give a good representation of the rheological behaviour of the suspensions over a wide range of rate of shear.

Apparent yield values and coefficients of rigidity may be obtained from either figure by the methods described. The apparent coefficients of rigidity may also be determined by the reciprocal extrapolation method. A comparison of the apparent properties as determined by the various methods appears in Figs. 5 and 6. It will be noted that there is some difference in the results. This is due to differences in interpretation and is a measure of the inaccuracies inherent in all methods. Since the suspensions are not really Bingham plastics none of the interpretations is really correct. Each however represents the data about equally well.

Returning to Fig. 4 it is seen that from data spanning a shear rate range of 5 to 1000 sec^{-1} the rheological performance may be estimated over substantially all rates of shear. Real or apparent yield values and coefficients or rigidity may be read directly from such a plot. Apparent viscosities may be read at any shear rate merely by observing where the data line at that shear rate cuts the "third scale".

A real appreciation of the rheological nature of a system may be obtained from a fully extended curve on Fig. 4.

Consider for example, the line for the 10% clay-water suspension. Compare it with the 1 centipoise or 0% clay-water line. The nature of the system precludes the existence of a true yield value and the data line is extended to zero shear rate—as for water itself. At shear rates of 1—10 sec^{-1}, unit shearing stresses about 10 times as great as for water are required for the clay-water system. The shear stress increases with increasing shear rate but more slowly than for water and at 100 and 1000 sec^{-1} the comparative shear stresses are respectively about 4.5 and 2.3 times those for water. The extension of the data line to the right indicates an asymptote of 1.9 centipoise. This is the apparent coefficient of rigidity of the suspension or its apparent viscosity at high rates of shear. Extending the convex portion of the data lines to the left indicates an apparent yield value of some 1.8 dynes per sq. cm. In other words, if one wished to approximate the behaviour of the suspension by the two Bingham constant these valves would be appropriate and the actual rheological behaviour would be fairly closely represented for all shear rates above 10 sec^{-1}.

In terms of apparent viscosities one may observe directly that the apparent viscosity of the 10% suspensions is over 100 centipoises at extremely low rates of shear; it decreases to 10 centipoises at a rate of shear of 25 sec^{-1}, to 5.5 centipoise at 100 sec^{-1}, to 2.2 centipoises at 1000 sec^{-1} and to a limiting value of 1.9 centipoise at very high shear rates.

Application of Data

While it is not the intent in this review to discuss design methods in which rheological data are used some reference to the application of such data seems appropriate. Rheological data are required for the design of systems for the pumping, transportation, mixing, and heating of non-Newtonian fluids, for the settling of particles in them and in all cases where the consistency of the fluid is important.

The commonest application is to pipeline transportation and to the calculation of pressure drop—flow rate relationships as function of line size and fluid properties. For Newtonian fluids the procedures are now well established both for laminar and turbulent flow conditions. Much less is known for non-Newtonian fluids although in the simpler cases methods have been developed.

For a true Bingham plastic in laminar motion the Buckingham equation has both theoretical and experimental backing. The equation is

$$\frac{8V}{D} = \frac{g_c}{\eta}\left[\frac{D\Delta P}{4L} - \frac{4}{3}\tau_y + \frac{1}{3}\frac{\tau_y^4}{(D\Delta P/4L)^3}\right]$$

where

V = average velocity, per ft. per sec.
D = pipe diam., ft.
η = coefficient of rigidity, lb_m per ft. sec.
g_c = 32.2 lb_m ft. per lb_f sec^2
L = length of pipe, ft.
τ_y = yield value, lb_f per $ft.^2$
ΔP = pressure drop, lb_f per $ft.^2$.

This equation may be rearranged in several ways. Govier and Winning[2] demonstrated by dimensional analysis that, for Bingham plastics, the friction factor, f, could be expressed as a function of $(DV\rho)/\eta$, a modified Reynolds number and, $(D\tau_y g_c)/V\eta$, a "yield number". In terms of these groups the Buckingham equation becomes

$$\frac{1}{R_m} = \frac{f}{16} - \frac{Y}{6R_m} + \frac{Y^4}{3f^3R_m^4}$$

where $f = \dfrac{g_c D\Delta P}{2V^2L}$, the friction factor

$$R_m = \frac{DV\rho}{\eta},$$

the modified Reynolds number

$$Y = \frac{D\tau_y g_c}{V\eta}, \text{ the yield number}$$

Perkins and Glick[7] have rearranged the Buckingham equation to the form

$$\frac{1}{R_m} = \frac{f}{16} - \frac{H}{6R_m^2} + \frac{H^4}{3f^3R_m^8}$$

where

$$H = YR_m = \frac{\tau_y D^2 \rho g_c}{\eta^2},$$

a dimensionless ratio suggested by Hedstrom[3] who has also prepared a graphical representation of the Buckingham equation in the form of f versus R_m with H as a parameter.

It is of interest to compare these rearranged forms of the Buckingham equation with that for Newtonians.

$$\frac{1}{R} = \frac{f}{16} \quad \text{where} \quad R = \frac{DV\rho}{\mu}$$

Under fully developed turbulent motion the Newtonian methods may be used for a Bingham with the substitution of the coefficient of rigidity for the Newtonian viscosity in the Reynolds number. One remaining difficulty is in connection with the transition zone. There is conclusive evidence to the effect that the transition from laminar to turbulent motion depends not only upon the (modified) Reynolds number but also upon diameter, yield value, velocity and coefficient of rigidity. Moreover the transition range is known to be very wide. The best present guide seems to be the observation that strict laminar flow extends only to a friction factor value of about 0.008.

In the case of pseudo plastics the situation is less clear. One procedure, satisfactory at reasonably high rates of shear, is to treat the pseudo plastic as an equivalent Bingham employing apparent values of the yield value and the coefficient of rigidity. Another procedure, proposed by Metzner[6] involves the use of the conventional (Newtonian) friction factor—Reynolds number correlation with a modified Reynolds number defined as

$$\frac{D^{n'}V^{2-n'}\rho}{\gamma}$$

where n' is a flow behaviour index approximated by the slope on logarithmic co-ordinates of the (dF/dA) – (dV/dX) relationship ; and

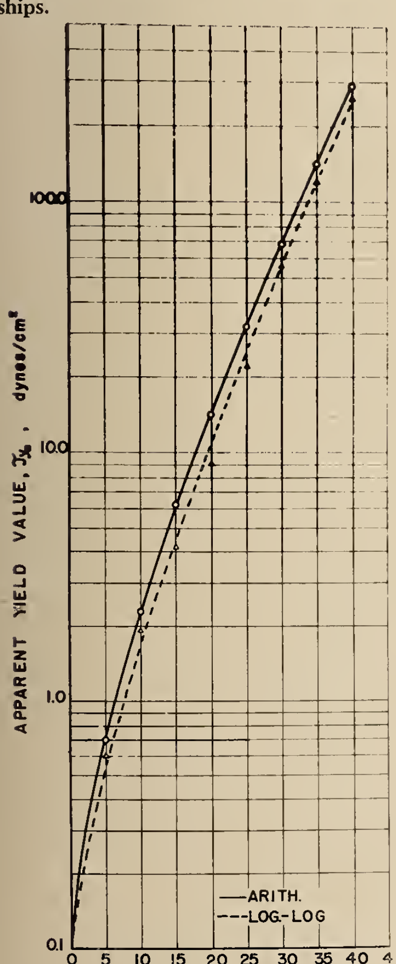
$$\gamma = g_c K' 8^{n'-1} \quad \text{where}$$

$$K' = K\frac{(3n'+1)^{n'}}{4n'} \quad \text{and}$$

$$K = \frac{dF/dA}{(dV/dX)}$$

Engineers are tempted to simplify the problem by trying to use a single apparent viscosity and to treat the fluid as though it were a Newtonian. This is satisfactory sometimes but it is also dangerous. The difficulty centres in the

Fig. 5. Apparent Yield Value Relationships.



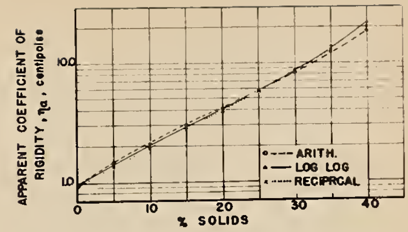


Fig. 6. Apparent Coefficient of Rigidity Relationships.

choice of the apparent viscosity. At what shear rate should it be taken? In turbulent motion the effective rate of shear is high and an apparent viscosity taken at 1000 or more reciprocal seconds appears appropriate. Such a value however is little different from the coefficient of rigidity or the apparent coefficient of rigidity so the procedure reduces to that described above. In laminar motion the rates of shear are much less and vary more over the flow section. The use of an apparent viscosity here is definitely not recommended and the Buckingham equation or some modification of it is to be preferred.

Generally speaking and in all applications the use of an apparent viscosity should be restricted to cases of reasonably constant rate of shear and the apparent viscosity should be evaluated at the rate of shear of interest.

Acknowledgement

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ENGINEERING STUDIES OF THE FRASER RIVER BASIN

(Continued from page 66)

Benefit Cost Studies: Mention has been made of benefit cost studies in connection with the Board's flood control and power investigations. In this case the application was rather a severe one in that the only benefit evaluated was that accruing from the production of electrical energy while the benefits of flood control and other water uses were not evaluated. On the other hand, due primarily to lack of adequate information, no attempt was made to include fish facility costs on the debit side. This rather arbitrary position will likely require further modification as more information on fishery and other water resource use becomes available.

One of the recommendations of the preliminary report is that a benefit cost study be carried out for the Lower Fraser Valley in which the cost of various degrees of flood protection might be compared with the benefits derived. While this would appear to be a very realistic approach, it is fraught with considerable complexity if applied too rigidly.

It is possible, theoretically, to study a valley and determine from different flood levels the value of the land and property damage resulting. However, while this may account for direct physical damage, it tends to ignore the fact that the valley is an economic unit in which the indirect effects of floods such as the disruption of communication lines may be more serious than local inundation. Even moderate flooding in such a case may disrupt the economic activities nearly as much as the more severe freshets.

Flood Plain Restrictions: It has been advocated by some that a river should, within certain limits, be allowed its flood plain or right of way and within this portion of the valley improvements would be limited to agricultural works which would not be damaged by flooding.

In the very early settlement of a valley it might be possible to introduce such restrictions. However, in frontier areas, governments are hesitant to impose limitations on newly developing regions. Hydrometric data is also usually scanty or non-existent so that it is difficult to define the proper channelway.

Some authorities also claim that restrictions within a river valley by government might imply a responsibility for damages should a record flood be experienced which invades the so-called safe area.

Conclusions

The foregoing has been an attempt to summarize some of the problems facing the Fraser River Board throughout its 12 yr. of investigational work and the expenditure of $1,440,000. This effort can be roughly divided into three distinct phases.

The first phase ran from 1948 to 1955 and included an intensive program of mapping and the collection of hydrometric and meteorological data.

The interpretation of this raw material with respect to flood control could be called the second phase and this terminated with the completion of the Interim Report in 1956.

The approach was then broadened to encompass both flood control and hydro-electric power under what is known as the Preliminary Report of 1958.

The Fraser River Board within the last month has started on a new four-year program which will include exploration of a number of the proposed damsites. While this drilling program is proceeding, fishery research and certain flood investigations in the Lower Fraser Valley will be carried out.

Generally, the very broad picture of how flood control and hydro-electric power may be realized has been painted. It remains now to start filling some blank spaces which, no doubt, will lead to a continuing broadening outlook of the use of the water resources of the Fraser River watershed.

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Appendix

Organization Fraser River Board

December 1948 to April 1955

Dominion-Provincial Board,

Fraser River Basin

Federal Government Members

1. Assistant Chief Engineer, Department of Public Works
2. District Hydraulic Engineer, Department of Mines
3. Chief Supervisor of Fisheries, Department of Fisheries
4. District Engineer, Department of Public Works

Provincial Government Members

5. Former Deputy Minister, Department of Public Works
6. Deputy Minister, Department of Lands
7. Inspector of Dykes Department of Lands
8. Deputy Minister Department of Fisheries
9. Comptroller of Water Rights Department of Lands

April 1955 to April 1956

Fraser River Board

1. Director, Engineering & Water Resources Branch, Canada Dept. N. A. & National Resources.
2. District Engineer (B.C.-Yukon) Water Resources Branch Canada Dept. N. A. & N. R.
3. Chief Supervisor of Fisheries for B.C. Canada Dept. of Fisheries
4. Deputy Minister, B.C. Department of Highways
5. Comptroller of Water Rights B.C. Department of Lands and Forests
6. Director of Surveys and Mapping, B.C. Department of Lands

April 1956 to 31 January 1959

Federal Government

1. Director, Engineering & Water Resources Branch
2. Chief Supervisor of Fisheries

Provincial Government

3. Comptroller of Water Rights
4. Director of Surveys and Mapping

A NOTE ON RAINFALL DATA ANALYSIS IN CEYLON

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Hunting Survey Corporation Ltd., Toronto

THE OBJECT of this brief paper is to point out certain of the precautions that have to be observed when using in one country hydrological techniques developed in another. The particular techniques with which it is concerned are those for (a) the filling out of the record of a raingauge station where its length is less than the period considered minimum for the particular study in question, and where the length of the record at other stations in the area is of the requisite length; and (b) the examination of all the data both actual and either interpolated or extrapolated under (a) for inconsistencies or changes and the making of the necessary adjustment of the data.

Objective (a) is achieved by calculating for the whole period and from a group of nearby stations the average rainfall for each month or season or year as the case may be and by obtaining from this and from the actual corresponding rainfall for any station during the period of record of that station a correlation ratio for each month or season, etc. The correlation ratio for the station and period, applied to the averages for those years for which there was no record, gives an acceptable approximation to the monthly, seasonal or annual values that are missing.

Objective (b) can be achieved by double mass plotting, that is plotting the accumulated station period (month, season or year) totals against the corresponding accumulated averages over the period under review.

These techniques have been found extremely useful in North Africa where they were developed. Here it is considered reasonable to base the average on a group of stations which do not all necessarily have a complete record for the period under review. Obviously there must be some minimum number of stations within the group having a complete record: it is for the hydrologist to judge from the quality and nature of the record what this minimum should be.

The object of the investigation referred to in this paper, of which the analysis of existing rainfall data formed a part, was to determine for a major river basin in Ceylon the rainfall-runoff relationship. The ultimate object of the whole investigation was to determine for this river basin the availability and monthly distribution of water for irrigation and hydro-electric power generation at various points in it. As only a few runoff recording stations have been in operation for a relatively short time, it was necessary to compute synthetic flow data. This entailed correlating runoff and rainfall for each month of each year of record and using the coefficients derived in this way for extrapolation of existing records and the preparation of computed flow data for other points in the basin.

Ceylon is fortunate, compared with many countries in a similar state of development, in having a very extensive and dense network of daily depth raingauge stations, the records of the earliest of which go back to about 1870. As in the case of more developed countries records are in many cases incomplete, gauge locations have been changed with or without a change of name and, more significant to the analysis, the density of the network has increased irregularly as and when funds have become available.

Raingauges fall into three categories in Ceylon: (i) the first class stations operated by the Meteorological Service directly, which are comparatively few in number, (ii) second class stations operated for the Meteorological Service by other government agencies (e.g. at police stations and hospitals), and (iii) co-operating stations, varying from first class to dubious: these are generally at tea and rubber estates; they maintain records in the form prescribed by the Meteorological Service and send the results to the latter. The observers employed vary from technical and subtechnical staff of the Meterological Service, through clerical staff of estates, to semi-literate or illiterate persons.

It was decided that a 50-year period of rainfall should be the basis of establishing means; and that, because of seasonal variations in the probable use of water for irrigation or hydro-electric power generation and the high monthly variability of rainfall, the data should be analysed monthly. 50 years of data are considered by most hydrologists as a reasonable compromise between what is desirable and what is practicable for the determination of most of the variation of rainfall and runoff that affect the design of dams and reservoirs. Furthermore the economic life of most major dams and structures is generally taken as 50 years and it is unusual to cater for events outside this scope except where risk to life or property justifies a greater degree of protection.

In the particular basin under review many of the raingauge stations had records for less than 50 years, which comprised the period 1907 through 1956.

For determination of the total onfall of rain on the various catchment and sub-catchment areas it was decided to use the Thiessen polygon method of weighting the rainfall records. The first step therefore was the double one of selecting from the total of available stations those having more than a certain minimum number of years of record and, from among these, those that gave the best geographical network for the Thiessen polygons. In the first attempt, and mainly in order to improve the Thiessen polygon network, a minimum of 10 years was considered acceptable.

In North American practice a 10-year record is considered by most authorities as sufficient for good correlation. This practice is satisfactory in North America mainly because of the generally high standard of reliability of records. When this project was set up there was no reason to suppose that the standard of reliability would not be at least reasonable. Indeed the large number of stations and the length of the majority of the records led one to expect a high standard and it was not until the analysis was well under way that evidence to the contrary began to emerge from the analysis itself.

In order to have comparable records it was decided to fill out the records of incomplete stations by extrapolation. The system used was that described in the opening paragraph, i.e to determine for each month for each station a correlation ratio relating the rainfall for that month to an average for the whole area for that month. Following generally the lines laid down in the *Hydrology Handbook* of the American Society of Civil Engineers, it was decided that the average for the month should be that for the whole basin including stations with incomplete records. This involved the assumption that over a long period and a sufficient number of stations, errors are self-compensating. Extrapolated data was calculated from the correlation ratios.

The next step was to check the results to determine whether the records had been affected by changes of exposure of the gauges or by changes in observing technique, etc. For this purpose double mass plotting of accumulated station monthly totals against the accumulated all-station monthly means, was resorted to. In theory this should have revealed, by changes in the slope of the plot, any non-climatic factors and the years in which they occurred: adjustment of the whole record for any particular station month could then be made on the basis of slope ratios.

All this work, involving a considerable mass of data, would have taken a very long time and larger numbers of appropriate local technicians than were in fact available in Ceylon. The greater part of the work was therefore performed, first in Canada and then in the United States, by electronic computer (the IBM 650) and the plotting by an automatic line plotter which had, fed to it, the data from the IBM 650.

When the first batch of double mass plots arrived — there were close to 2,000 altogether — it immediately became obvious that slope determination was going to be difficult if not impossible owing to the enormous number of short period slope changes. On consideration it was decided that it would materially help in identifying dates of significant changes to have annual double mass plots prepared: clearly if the rainfall record for any station had been affected by a change of exposure, etc. this should show up on the annual plot which would then be used as a guide to the identification of dates. Monthly totals were considered to be more liable to fortuitous variations due to the observer being careless or ill or on holiday. Experience elsewhere led one to believe that absence of the observer due to illness or holiday could sometimes mean that the record had been filled in by not very enlightened guesswork!

Very few stations on the annual plots showed identifiable changes of slope but where they were identifiable the dates so determined were used in attempting to fit slopes to the monthly plots.

This still left a majority of the station monthly plots indeterminable as to slope changes except by guessing. Obviously this would not do. A careful check of the plots showed that in many cases, in addition to what appeared to be fortuitous slope changes, there was a distinct (sometimes very great) change in slope between the extrapolated segment and the factual data segment. This pointed to the method of calculation of the correlation ratios being at fault. When the dates of slope changes were first determined it was noted that very often they occurred around the years 1947, 1938, 1923, 1918, and 1914. Eventually the explanation came from examination of a graphical representation of the lengths of actual and extrapolated record. At or around each of the dates above there was a significant increase in the number of raingauges.

At this point it is necessary to digress. Ceylon lies in the monsoon belt and its weather is basically dependent on the annual movement north and south of the intertropical front. This in simplified terms is the line of demarcation between the northeast 'trade winds' of the Northern Hemisphere and the equatorial westerlies and between the two air masses concerned. The actual zone of contact is the zone known to sailors as the doldrums, characterized by intense local instability, variable winds, violent thunderstorms, etc. The movement of the intertropical front is not exactly predictable at present as regards its date of arrival at any particular latitude. The combination of this basic climatological background and the topography of the Island is responsible for the enormously varying rainfall experienced. In terms of depth the variation is from around 40 in. annually to around 250 in.: in terms of season one part of the island derives much of its rain from the northeast monsoon in the months October through January, while another derives much from the southwest monsoon from May through October. Yet another part appears to be under the influence of both monsoons and a fourth zone—along the southwest coast—appears to be under the influence of orographic effects on the doldrum phase.

In most years the periods March/April and September/October are those in which the actual intertropical front moves north and south respectively over the island — this is what has just been referred to as the doldrum phase. Rainfall in September and October, occurring as it does immediately before or after one or other of the monsoons, can be considered as belonging to one or the other according to circumstances.

Reverting to the study of rainfall data it became clear on reconsideration that the assumption that 'over a long period and a sufficient number of stations errors are self-compensating' was not valid. This is because the errors in this case are not true errors of observation or siting, but are systematically inherent in the weather system. If new stations had been brought into the record each time in numbers proportional to the numbers originally existing in different weather areas, the assumption would have been valid. As it was, the introduction of varying numbers from areas having, in some cases, exactly opposed monthly rainfall distribution introduced errors in the calculation of correlation ratios and falsified the accumulated total of mean monthly rainfalls — the abscissa values of the double mass plot.

Once identified, the trouble could fairly quickly be put right. Scrutiny of the rainfall records and of the monthly means for all stations published by the Colombo Observatory (admittedly including inaccuracies but reliable enough for indications of the stations' monthly distribution of rain-

(Continued on page 92)

Accreditation for Canadian Engineering Curricula?

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"But on every subject on which difference of opinion is possible, the truth depends on a balance to be struck between two sets of conflicting reasons."

John Stuart Mill
On Liberty

ARE THE FACULTIES of Engineering and Applied Science in Canadian Universities doing work of the calibre that is required in engineering education? Are our engineering graduates the sort of men who can contribute greatly to the development of Canadian industry? There is evidence that some of our graduates have the engineering ability, the bold imagination, and the enterprise to do more than help to operate a satellite economy. But are we educating our engineering graduates in a way which will ensure that a significant proportion of them have the technical competence, the depth of understanding and the breadth of view necessary to assure the engineering future of Canada?

One hears a great deal about the loss of our best brains to the United States, and we must admit that there is a significant migration of talent to the south. Whether this migration of talent is a loss to the nation is a good question for debate of course, because if we imagine ourselves without the benefits of American technology—to which these "lost brains" make their contribution—we can see that it is not necessarily all loss. The very fact that some of our best engineering talent finds its way across the border and in many cases does well in an atmosphere of keen competition is some assurance that all is not wrong with our system of engineering education. Some would argue that this fact is proof that we are doing very well and that no improvement need be contemplated. Some indeed would probably hold that our engineering graduates are superior in all respects to their American counterparts, will inevitably dominate them in any competitive situation, and need no improvement.

To argue this way is to blind oneself to the excellence of a large segment of American engineering education. The attachment of undue weight to the success of some of our own engineering graduates in the United States should also be treated with caution. Men who have inherent qualities of intelligence, ability, energy and ambition will do well in the world regardless of the educational system to which they are exposed in a university for four or five years. Indeed many will do well without such exposure. So it is pertinent to ask whether our best engineering graduates do well at home or abroad because of the quality of our engineering education, in spite of it, or whether their success is unrelated to their education.

There is real doubt about whether this question can be answered. The effects of any educational system are difficult to measure in a quantitative way. Furthermore changes take place slowly and the effects of great changes may not be felt for many years. If the changes are for the worse they may not be recognized as such for a long time. The present concern in the United States over the effects of the educational philosophy of John Dewey upon high school education is a good example. It is not enough however to say that we ought not to contemplate change because things at present are good and any change is likely to make them worse. Thus, while it may be impossible to answer specifically the questions which have just been raised, it is well worth while and indeed almost imperative that they be considered, and that the results of their thoughtful consideration be used as a guide in appraising our present methods of educating engineers.

Accreditation—Pro and Con

What are the merits and drawbacks of a system of inspection and accreditation in relation to our present arrangements for educating engineers? There are those who feel that such a system is a practical way of insuring the maintenance of high standards of professional education among engineers, and of fostering the development of stronger faculties of engineering and applied science. On the other hand there is a strong feeling in other quarters that this procedure would serve no useful purpose and would be detrimental to the best interests of university education. This view seems to be held quite generally by the universities themselves.

The number of engineering faculties in this country has never been very large, and for a long time there was no change in the number of institutions offering degrees in engineering. The past ten years however have seen a marked increase in the number of institutions involved in engineering education. Not all of these institutions have embarked upon the presentation of engineering curricula of the traditional type. This new activity has helped to stimulate interest in accreditation procedures, and in some cases the provincial associations of professional engineers have seen fit to institute inspection and accreditation procedures of a rudimentary sort.

The situation has in it the seeds of a conflict of interests. Traditionally the engineering profession in Canada has left the maintenance of standards of education leading to admission to the profession almost entirely to the universities. It has been argued that the universities have been our benefactors in this matter, and that the recognition which our profession receives is due in no small measure to the fact that our members increasingly have come from the universities. This is the point of view expressed so ably a few years ago by Dr. Claude Bissell,[1] then Vice-President, now President of the University of Toronto, when, holding up the medical profession as an example, he said, "The practice of medicine was ennobled by its marriage to liberal education and the medical profession thus attained its status as a learned and respected group." Yet it should be added that what Dr. Bissell failed to say was that in Canada now the medical profession has considerable influence through external accreditation and examination requirements upon the teaching of medical undergraduates in the universities.

Dr. Bissell made these remarks and others, none of which was favorable to the concept of accreditation, to an assembly in Toronto of the Engineers' Council for Professional Development. This body originated in the United States in 1932 a system of inspecting and accrediting engineering curricula. Since that time it has carried out this program with increasing influence until now it is one of the dominating features of engineering education in the United States. In effect Dr. Bissell told this assembly of American engineers and engineering educators dedicated to the accreditation program that Canadian universities wanted to have nothing to do with it. It is by no means certain that all presidents and deans in American universities were unsympathetic to his remarks.

Dr. Bissell's objections went right to the core of the matter. He said, "It would be a pity if the centre of educational thought were to shift from the universities themselves to any outside body, no matter how reputable and wise that body might be." This is what the accreditation system is doing for a great many of the engineering schools in the United States. Those within ECPD who dominate the thought and action of its Education and Accreditation Committee are without exception engineering educators. However, the great influence which they exert upon almost all American engineering schools and faculties is that of an external group. And while the inspection which may lead to accreditation must be requested and paid for by the institution, the prestige of ECPD accreditation and the pressure to conform is such that few institutions ignore the accrediting program.

But there is another side to the coin. Few who are informed would deny that in Canada we have engineering faculties where the curricula are backward, where the human and physical resources needed to effect improvement are lacking, and even where realistic, sympathetic and active consideration of the needs of the engineering education process is absent, inadequate or belated. We have engineering professional schools within our universities, but necessarily and probably rightly they are not considered to be the prime business of the universities. We do not have the sort of leadership for our engineering faculties which is provided in the United States by the great institutes of technology, except insofar as we look to those in the United States for leadership. Julius A. Stratton, eleventh president of the Massachusetts Institute of Technology, has said, "There rests upon such institutions as ours a heavy responsibility to provide standards of excellence, to set new patterns, to give leadership, and to lift the sights of all."[2] Lacking this sort of national influence, the strength which can come from a few institutions of high calibre which devote their prime efforts to science and engineering, we may well consider whether the profession in Canada is not justified in concerning itself directly with the education of its members in the universities.

Some may claim that nowhere but in a university can a young man gain the broad education which will fit him for professional life. But we should not make the mistake of assuming that the institute of technology is merely a trainer of technicians. These institutions have come to regard themselves as *universities polarized around science*. With some justification they might claim that they do a better job of educating their engineering undergraduates in the broad sense than do our own universities. There may be wisdom in the waggish saying that the universities *humanize the scientists* while the institutes of technology merely *Simoniz the humanists*. Nevertheless, when we think of the lack of interest in and indeed respect for the humanities which is evident among many of our engineering undergraduates and even in some of the products of our engineering courses, we should not lightly claim that all is well.

Consider also this statement (in context it was not made as an argument in favour of an accreditation system, but it can be taken as such): "We need only recall the retrogression of American colleges in the first decades of the last century when the rapid multiplication of institutions over-ran the support available and a widespread mediocrity enveloped them. In the longer past we might recall the lethargy of the European universities in the sixteenth, seventeenth, and eighteenth centuries. Cultural, social, and financial forces have from time to time diminished the vigour of universities; in the light of the past we cannot take for granted that our present-day system is immune to deterioration or that it does not require alert and vigorous efforts to keep it strong."[3] One might argue that as far as the engineering profession is concerned a systematic inspection and accreditation procedure would be a contribution to such "alert and vigorous efforts".

ECPD Accreditation

In considering the merits and demerits of an inspection and accreditation system it will be useful to consider in some detail the practices which have evolved in the United States over the past twenty-seven years. We may not like them, we may not want them, but at least we ought to examine the system for it involves a good deal more than a cursory inspection and it is no automatic rubber-stamp routine. We ought also to examine what we do in Canada in this direction, for even now there are embryonic forms of accreditation in this country.

Accreditation of engineering curricula in the United States is carried out by the Engineers' Council for Professional Development through its Education and Accreditation Committee.[4] This committee comprises a chairman and two representatives from each of seven geographical regions. These two are designated regional chairman and vice-chairman. In addition the immediate past-chairman sits on the committee as does a representative from the Engineering Institute of Canada.

The accreditation procedure used by the ECPD is based upon well-defined general policies.[5] The procedure is initiated only at the request of the institution. This policy applies when initial accreditation is involved and also when extension of an existing accreditation is sought. Accreditation is never granted for longer than a five year period. Shorter periods are often authorized for special reasons although accreditation for less than a three year period is not usual. ECPD accredits curricula and not institutions. It would be quite possible for an institution to have an accredited curriculum in civil engineering and a nonaccredited curriculum in electrical engineering.

Accreditation procedure involves the submission of written data by the institution to ECPD and subsequent inspection on the spot by a visiting team whose business it is to evaluate qualitative aspects of the institution and the curricula under consideration. The recommendations of the visiting committee are reviewed by the Council's Education and Accreditation Committee and later by the Council itself before it arrives at a decision.

There are other policies which are important to the maintenance of high standards in the accreditation program. No form of accreditation is employed at present for graduate curricula. Even for undergraduate curricula the ECPD aims to ensure "the avoidance of rigid standards as a basis for accrediting, in order to prevent standardization and ossification of engineering education and to encourage well-planned experimentation."[5] Further, the ECPD publishes "a list of accredited curricula only, with no information available to any person (other than proper officials of the institution concerned) as to whether any curriculum or institution not on the accredited list has been under consideration by ECPD".

Curriculum Inspection

Consider now the mechanics of a curriculum inspection. When a request is received from an institution for consideration of one or more curricula with a view to accreditation a questionnaire[6] is sent to the institution. This questionnaire covers all the important aspects of the institution's operations insofar as they relate to the curricula under consideration. It provides the inspectors with information which makes possible the efficient use of their time during the inspection process. The bare documents total about twenty pages and inquire searchingly into the characteristics of the institution as a whole including its type of control and its financing; the features of the engineering unit; its finances both in total and as they are distributed among the various departments; policies toward faculty including salary ranges and averages; physical facilities including buildings, laboratory equipment and libraries; enrolment statistics; admission requirements; graduation requirements; courses taught in the curricula for which accreditation is sought; the objectives of the institution insofar as they relate to these curricula; and finally the background of all staff members whose work affects these curricula. Copies of the completed questionnaire are supplied to the chairman of the ECPD Education and Accreditation Committee, to the regional chairman and vice-chairman concerned, and to the members of the team of inspectors which is to visit the institution.

Members of inspecting teams are chosen from the ranks of engineers of high repute in industry, private practice, and education. The great majority of them however are engineering educators. For each curriculum which is to be inspected the visiting team will have at least one member whose field of engineering corresponds to that curriculum. Customarily the regional chairman or the vice-chairman also is a member of every visiting team within the region. Thus, when the report of an inspection team comes to the Accreditation Committee there is a member present who has first-hand knowledge of the case. Those who are appointed to positions as regional representatives on the Committee are men with extensive experience and proven ability in the techniques of inspection.

An inspection is carried out over a two-day period. The chairman of the visiting team is expected to familiarize himself beforehand with the reports and actions on previous inspections if any. He is also responsible for the selection of a balanced team. The team meets for a preparatory session the evening before the inspection is scheduled to begin. On the following morning the visitors assemble with the dean or chief administrative officer of the engineering programme in the institution. After this meeting they may meet the president. The team then splits up and the members proceed with their individual inspection assignments. In the evening they meet again to discuss and correlate their findings, and to see whether such weaknesses as may have been discovered are general or peculiar only to certain departments. The morning of the second day is allotted to completion of the inspection and such cross-checking of the findings of the first day as may be necessary.

In the afternoon of the second day the team meets to reach agreement upon the points which the members feel should be included in the written report, and to decide what recommendation should be made to the ECPD Education and Accreditation Committee. The committee then meets once more with the dean and possibly the president to review its findings. The committee reports only upon facts and observations at this point, and ascertains whether the officials of the institution agree with the findings. No intimation is given as to whether the curricula inspected will be recommended for accreditation or not. After this meeting the visit to the institution is complete.

The formulation of a written report is the responsibility of the chairman of the visiting committee. To assist him in this task each team member is expected to prepare a report covering the assignments which he has carried out. The consolidated committee report has two distinct portions. One of these is confidential and for perusal only by the responsible officials of the ECPD and its Education and Accreditation Committee. It contains the statements of observations, facts, and opinions relating to the curricula under consideration as well as to the departments and facilities directly related to the support of these curricula. This portion of the report also contains the visiting committee's recommendations to the Education and Accreditation Committee for accrediting action if any.

The second portion of the report comprises a statement of less confidential nature which can be transmitted to the institution concerned. The objective is not merely to indicate to the institution the basis for the accrediting action, but to assist in improving its educational standards where such improvement is believed to be necessary or desirable, and also to point out the strong points. Great emphasis is placed upon the tactful wording of the portion of the report which is sent to the institution, since it is intended to instil a desire for action and not resentment. The ECPD aims to effect general improvement in the level of engineering education and not merely to provide minimum standards. Those institutions which are accredited, even the best of them, have in these reports means for evaluating their shortcomings. The report may also provide some of the stimulus required to encourage improvement.

The reports of the team members and the chairman's consolidated report together form a rather voluminous document. The Education and Accreditation Committee meets twice a year, in June and October, to consider many of these reports. After thorough consideration it frames its recommendations to Council. These recommendations are carried by the Committee chairman to the Council which considers and acts upon them once a year at the annual meeting of ECPD in October. No word is transmitted to the institution until action has been taken by the Council. The visiting committee's comments are then despatched along with the Council's decision on accreditation.

Accreditation Criteria

More important than the mechanics of accreditation is a consideration of what the ECPD looks for and expects in an accreditable curriculum. Under the Rules of Procedure of the ECPD the Education and Accreditation Committee is charged to "develop, and modify when necessary, criteria for colleges of engineering which will ensure to their graduates a sound educational foundation for the practice of engineering".

The basic criteria for accreditation purposes were set forth in a statement approved by the ECPD in 1933. While these criteria have not been modified in the intervening years they have been supplemented with additional criteria. The original criteria laid emphasis upon both the qualitative and quantitative aspects of the curricculum. The qualitative aspects include the extent to which the curriculum develops the ability to design — this being regarded as one of the chief distinguishing characteristics of the engineer; the "qualifications, experience, intellectual interests, attainments, and professional productivity of members of faculty"; the "standards and quality of instruction" both in the engineering departments involved in the curriculum and in the scientific and non-scientific departments contributing to it; the relationship of scientific training in the early years to engineering teaching in the later years; the "scholastic work of students," the records established by graduates of the curriculum — both in graduate schools and in practice; and finally the "attitude and policy of administration toward its engineering division and toward teaching, research, and scholarly production."

While the qualitative features of a curriculum are most readily evaluated by the visiting committee while at the institution the quantitative aspects are readily communicated in print. Substantially the quantitative criteria used by the ECPD are those which have already been presented as the subject matter of the questionnaire.

With the passage of time and intensification of the work and influence of the ECPD Education and Accreditation Committee there arose a need and demand for more precise statement of what the committee and ECPD regarded as adequate organization and content for a curriculum. In 1955 the Council adopted a set of *additional criteria* which set out in some detail the minimum requirements for work covered in basic sciences, engineering sciences, engineering analysis and design, and the humanities. Because it was found that these additional criteria were being interpreted often in too narrow a sense the statement of them has been revised subsequently. This revision, which first appeared in the ECPD Annual Report for 1958, emphasizes the Council's basic policy of avoiding rigid standards which might discourage new developments and experimentation.

An approvable curriculum contains "at least the equivalent of one academic year of basic sciences, about half of which is mathematics beyond trigonometry."[5] Basic science is understood to include mathematics, physics, chemistry and geology, with emphasis upon the teaching of fundamental natural principles and their quantitative expression. Engineering science on the other hand is understood to mean the organized body of knowledge within the scope of the word science which forms a *bridge between basic science and engineering*. While this distinction may be difficult to interpret, particularly when there are institutions within the acquaintance of most in which basic science is taught within engineering departments and others in which engineering science is taught by basic science departments, it is a meaningful one. The criteria of 1955 specified mechanics of solids; fluid mechanics; thermodynamics; transfer and rate mechanisms; electrical fields, circuits and electronics; and the nature and properties of materials as engineering sciences. It was specified also that at least the equivalent of one academic year should be devoted to these sciences. The more recent statement however is less specific. It recognizes a "merging of boundaries between the basic and engineering sciences," expresses more concern with the breadth and depth of coverage in both, and lays less emphasis upon the division of time between the two. This change reflects the tendency in the United States to expand the scientific content of engineering curricula.

The additional criteria also call for at least the equivalent of one-half of an academic year devoted to engineering analysis, design and engineering systems. A further requirement is that one-half to a full year be devoted to studies in the *humanistic-social* area. To emphasize that more than lip service is to be paid to the latter, and to ensure that the subjects are chosen for their cultural value and not merely for their utility, it is specified that at least one-half year should comprise study of such subjects as history, economics, government, literature, sociology, philosophy, psychology, or fine arts, and should not include such courses as accounting, industrial management, finance, personnel administration, or military studies. It is understood that the whole degree programme must require a period of study of not less than four full academic years.

Canadian Activity

Such is the accrediting system sponsored in the United States by the ECPD. What equivalent if any have we in Canada at the present time? Certainly we have no widely known system. We have no regularly maintained and publicized list of accredited curricula. No national engineering body attempts to speak publicly for the profession in Canada on this subject. The Engineering Institute of Canada and the provincial associations are however not inactive in the matter.

The EIC interests itself in educational standards by virtue of its stated aim "to develop and maintain high standards in the engineering profession." This aim is the basis for EIC membership in the ECPD, and it is the reason for ECPD activity in the accreditation field in the United States. The ECPD, like the EIC, is not concerned with the licensing of engineers to practise, even though the licensing bodies have a direct interest in the ECPD. The National Council of State Boards of Engineering Examiners is one of the eight constituent bodies.

The measure of the extent of EIC participation in the accrediting field is the publication of a list of Canadian Universities with the engineering courses which they offer[5] along with the ECPD list of *Accredited Curricula Leading to First Degrees in the United States*. For each course there is a statement to indicate whether graduation from it is considered formally to fulfil the academic requirements for membership in or registration with the Chemical Institute of Canada, the Engineering Institute of Canada, the Canadian Institute of Mining and Metallurgy, and the various provincial associations (Corporation in Quebec) of professional engineers. The specific statement is made that publication of the list "does not imply accreditation by

ECPD or by any Canadian Organization." In the absence of initiative from those universities which have only recently begun to grant engineering degrees in Canada none of their names or the courses which they offer appear on the list in the Annual Report of ECPD for 1958.

Some of the provincial associations have become involved in the accreditation of curricula, notably in Ontario where in the past few years several universities have embarked upon new programmes leading to engineering degrees. The Ontario Association[7] set up in April, 1957, an accreditation committee. It operates through ad hoc visiting subcommittees. When an application is received for accreditation of a course one of these subcommittees visits the university in question and reports upon the staff, laboratory facilities, class room accommodation, and degree proposed. Final action is the responsibility of the Council of the Association. These arrangements are patterned very closely upon those used by ECPD, although the objective in a sense is different.

In other provinces in Canada[8] the associations of professional engineers usually accept the standard set by the provincial university as a measure of the academic requirement for registration. The standards of other institutions within or outside of the province are judged by comparison with the provincial institution.

Appraisal

Canadian practices differ in several ways from those used in the United States. Many of these are apparent from the foregoing account. Accreditation in Canada, where it exists, does so because of its relation to registration. In the United States a licensing body may see fit to accept graduation from an ECPD accredited curriculum as a prerequisite or at least a qualification for registration, but ECPD has no registration authority. There is another important difference. Accreditation by ECPD is for a limited period only. In Canada there is no form of accreditation which carries with it a specified time limit.

Taking into account the inertia to which both professional associations and universities are subject, one can see that without periodic review a course of studies or curriculum in a particular institution could deteriorate to a low standard and remain there for a long time before action was taken. Nor is inertia the only reason for such a state of affairs. There are a host of possible reasons including lack of funds. Responsible outside authority can be a potent influence, perhaps even one which the institution might welcome in such cases, for the improvement of standards. Deterioration is not something which can occur only in small and obscure universities. It can occur in specific departments in the best or the largest or the wealthiest of institutions. The main argument for a professional organization taking a direct interest in such situations is that the professional group can claim a duty to protect itself and the public. The public may be involved in two ways. It may be adversely affected by the incompetence of those who have followed inferior courses of study. It may also be affected in the sense that young men may be led to register in courses of study which they may judge to be excellent because of the high reputation of the university as a whole, but which in fact may be quite inferior among professional courses in the selected field.

The practice in some provinces of setting the provincial university up as the standard is only a very informal sort of accrediting, and of course it leaves the provincial university free to regulate its own standards. There is nothing in these arrangements to promote a national standard either of minimum requirements or of excellence. It is easy at this point to slip into a discussion of provincial and national responsibilities in the field of education and professional registration. These matters are under provincial control and few seriously question the desirability or feasibility of attempting to make any change. There is however nothing illegal or even necessarily undesirable about attempting to influence for better on a national scale the standards of education for a profession, there being nothing to bind any institution legally to accept such influence. We already have in education for the medical profession strong influences of this sort which cross not only provincial but national boundaries.

Summary

An attempt has been made here to present arguments both for and against the institution of some form of nation-wide accrediting of engineering courses. A description has been given of the accrediting systems already in use for engineering curricula in the United States and Canada. If greater space has been given to the case for accreditation, it is not necessarily because the author is firmly convinced that such a system would be a definite asset to our country and profession, but rather to stimulate thought and even provoke argument about a subject which we are likely to treat with too much complacency.

So often when enquiry has been made as to why we do not have a more active accreditation scheme in this country the answer is altogether vague, or perhaps to the effect that our engineering schools have been long with us and are generally agreed to be excellent — after all we graduated from them so they must be. Then again it has been said that our universities or our faculties of engineering and applied science have been asked whether they would like to see a system of accreditation instituted, and they have replied with one voice, "No." The profession seems to accept this "No" without question. What does not seem to be realized is that our universities look upon this as interference and naturally they do not want to be interfered with. Their position is sound; the universities must be free if they are to maintain their respect as universities; they do not want to receive "letters to college presidents"[9] from representatives of a profession telling them how to improve their engineering faculties—no matter how ably, diplomatically, and sympathetically the comments may be written.

But the position of the profession is equally sound if it wishes to exert efforts to better the educational background of its members for the benefit of both profession and public, and if it can see that there are cases where an educational program attaches secondary importance to engineering or where there is lack of sympathetic or informed understanding of the needs, objectives, and requirements of a program in engineering education. Reference has already been made to the opinions expressed by Dr. Bissell of the University of Toronto. His remarks should be supplemented with a reading of the discussion of them by Dean Hardy[10] of the University of Alberta. Dean Hardy contends that "The engineering profession in Canada relies completely upon the universities for the standard of engineering education, but the universities have no inherent right to the responsibility."

What is needed of course is effective cooperation between the universities and the profession, and the real question is whether a system of accreditation would foster such cooperation in greater measure. There should be no basis for concern that matters relating to accreditation would be placed by the profession in the hands of engineers of great competence in their own fields but with little understanding of or sympathy for the aims and essential characteristics of a university. Experience has shown that in both the United States and Canada these matters have been left almost entirely in the hands of professional engineering educators, many of them university deans of eminence. We ought, however, seriously to ask ourselves whether the stimulus of such formal cooperation between the profession and the universities is needed as a supplement to the stimuli which our engineering faculties now receive. They are at present subject to the interplay of a host of forces as well as to subtle and informal influences some of which relate to competition and some to cooperation. The success of an accreditation system involves many complex human factors, but the potential rewards may be worth seeking. The question is not simple, nor is there likely to be a simple answer; but it is important, and our profession ought to give it serious consideration.

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ACCREDITATION FOR CANADIAN ENGINEERING CURRICULA?

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fall) indicated that the stations in the basin could be assigned to one or other of three groupings in each of which the distribution followed a reasonably regular pattern. At the same time it was considered that enough variation within the groups still existed to make long period extrapolation risky so that all stations were rejected in which extrapolation exceeding two-thirds of the actual length of record would be required to produce a 50-yr. record.

Within each group of stations which, for convenience, were called the Northeast Monsoon, Mixed Monsoon, and Southwest Monsoon groups, averages were determined for that group from those stations within it having the full 50 yr. of record; correlation ratios were determined and extrapolated monthly rainfall totals calculated.

The reason why these techniques did not work out as originally used lies entirely in the different climatic conditions obtaining in North America and in Ceylon. In North America and within the area of any particular catchment under study there is little variation in type of weather. Raingauge stations may, due to differences of altitude, general topography, aspect, etc. show wide variations in daily, monthly, seasonal and annual depths but, within such catchments the periods of relatively higher and lower precipitation will be substantially the same all over the catchment. Really wide variations obviously exist within North America, but at such geographical distances apart as to make them of no practical signficance in relation to any individual catchment area. The same could, in practice, be said to apply to the whole of the temperate zones: the same can indeed be said to apply to some areas of Africa and Asia.

Where, as in Ceylon, the weather system is not homogeneous over the whole of the very small island, the technique can still be applied but with modifications. These modifications can be generalized so as to apply to the areas where conditions are not homogeneous. They can be summarised as follows:

1. Where evidence exists of lack of homogeneity of the weather type over the area being studied it is advisable to limit wherever possible the extent of extrapolation of data. This is because of the difficulty of identifying the boundaries of weather types: along the boundaries there is much shading due to stations being sometimes more under the influence of one type and sometimes more under the influence of another. Extrapolation of two-thirds of the length of the actual record is considered the maximum permissible until further information is available. However the setting of such a limit is best left to the experience of the hydrologist undertaking the study.

2. It is essential to identfy and map as accurately as possible areas within which the seasonal or monthly distribution of rainfall is fairly homogeneous and to sort the raingauge station records into corresponding groups. Even if the basis of study is annual, the same applies, for the rainfall in one part of the area in one season may spring (as in Ceylon) from causes totally distinct from those causing the rainfall in another part of the area.

3. Having sorted the raingauge stations into appropriate categories the only further modification indicated is to calculate the monthly, seasonal, or annual averages for the group from **only** those stations within the group having a complete record for the period under study. It is easy to imagine areas where the literal observance of this modification would leave too small a group for the establishment of averages and in such a case the hydrologist must rely on his experience: often such areas have such a thin network of raingauges that it is not possible to adhere to these recommendations. The same may be said to apply to some parts of Canada, but with the reservation that in general North American techniques can be applied without modifications.

Even in North America where the techniques used originated, double mass analysis of hydrological data has not been widely used. This is partly because before the advent of the digital computer such as the IBM 650 it was generally impracticable or uneconomic to deal with the mass of data involved: and partly because often the quality of data is good enough for the method to be dispensed with.

And so the kind of problem with which this paper deals is at present comparatively rare. If any general recommendation can be made, apart from the specific recommendations made above in respect of areas where lack of homogeneity is known to exist, it is that each new rainfall study must be assumed to be distinct and unrelated to other studies until reliable evidence to the contrary is available. In the study described, parallels with other studies were assumed until evidence to the contrary was available.

Underdevelopment is very often due to inadequacy or uneven seasonal distribution, or even to excess of rainfall with its attendant problems of damaging floods and denudation. Development in the physical sense will most often take the form of irrigation and/or hydroelectric power generation and both these require at least seasonal, and often monthly, analysis of hydrological data. It is essential therefore that in such countries a general picture of the rainfall distribution should be obtained as a first step and that the hydrologist should consciously try to identify different weather types and map them.

ENGINEERING FOR EXPORT

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MORE THAN at any time in the past, engineers are playing a vital role in the development of international trade. On the site of great works abroad, in the design office, on the production line, as consultants, as leaders of industry, engineers are making an increased contribution to trade between nations. In this, the modern engineer is following in the footsteps of his immediate predecessors of the Industrial Revolution and the days of colonial expansion. He may even be emulating those earliest engineers, the men who developed the very beginnings of technology. For the stimulus that drives men to trade with other nations is as old as man himself. Pressures of population, struggle with environment, harnessing of nature, migrations of technological invention, the mere struggle for survival have combined with the irrepressible will of man to seek new and fresher fields.

The contrast of today with the past lies in the vastly accelerated pace of development as communications have improved and scientific discoveries have come to add a measure of orderliness to the cruder efforts of earlier days. Today, engineering participates in trade against a background of intricate technology and complex international organization. The range of engineering products traded between nations includes the very simplest apparatus as well as such highly developed products as electronic components, chemical processing plant and large scale engineering works involving coordinated construction procedures. Such international organizations as the United Nations, NATO, World Bank and Colombo Plan and technical assistance programmes all play a part in spreading trade in technological commodities.

The movement of engineering products and services between nations is taking place under the impetus of such influences as money seeking investment fields, entrepreneurs venturing into new endeavours, industrial expansion and the vast programmes for development. These are associated with the determination of the newer nations of the world to secure for themselves the benefits of an improved material standard of living. In this last respect, the newer nations of Asia, Africa, Latin America, The West Indies, the Middle East are not only engaged in their own efforts. They are being assisted through vast international and bilateral programmes which include basic resources development as well as progressive industrialization in all sectors. The requirements of these economically underdeveloped countries pose at once an opportunity and a challenge to those countries that have developed engineering equipment and services of a type that are needed to bolster economies in need of development. In this respect, Canadian engineers and Canada's engineering industry are meeting the challenge and will undoubtedly continue to do so at a greater rate, as it is increasingly realized that Canada's stage of development is remarkably close to the type of development that many of the newer nations now need and will continue to need for some years to come.

Fig. 1. Model of a pulp and fine paper mill now being built near Cairo, Egypt. A Canadian firm acted as consultants, made the layout, and are supervising the engineering.

Most of us are, of course, implicitly aware of the situation as it stands today but few of us have the opportunity to participate in the whole and to observe the overall scene and its many interconnections. The Foreign Trade Service not only furnishes assistance to industry as required, but provides a vantage point from which useful observations can be made.

We in the Foreign Trade Service are in touch with the engineering industry in all its phases. We have come to know the consulting engineer and the pride he so correctly takes in the engineering code of professional ethics, the manufacturer and his almost traditional but wise caution, the contractor and his daring and spirit of risk-taking. We have sensed in all an almost wistful wish that one might borrow from the other a little of that which makes for the other's strength. The consulting engineer would like to be a little more flexible in his arangements with a client, and wonders if he might not correctly do so in other lands. The manufacturer, who is accustomed to selling on his reputation or to filling orders at home but always concerned that a proper return is made on heavy capital investment, wonders if he might not reconsider his method of pricing, manufacturing procedures and standards, taking a risk on closer pricing for export. The contractor, a risk taker and entrepreneur at heart, yearns for more stability. At times, all three decide that it is to their best interest, as well as to that of the client, to join in a marriage of convenience as a consortium, bringing to bear a blended mixture of all three approaches. All three, of course, realize that the domestic market in the long run is seldom if ever a sufficient outlet for the kind of special services and products that engineering firms are wont to provide. Whether alone or together, they have a common interest in exporting.

Whatever their guiding philosophy, whether they be consultants, manufacturers or contractors, most firms as can be imagined have some very practical questions which they would like to have answered. First and foremost, of course, is the question: What are the advantages of foreign markets for engineering services and equipment? Next come the questions: What conditions or obstacles are we likely to encounter abroad; what are the methods of coping with these conditions; what are the opportunities; what are Canadians now doing in this field?

Let us now discuss some possible answers to these questions.

What Are The Advantages

The export market offers a useful or even essential adjunct to a limited domestic market. Specially-made equipment, and specialized services, are in limited demand in any one country and at any one time. Even in those countries where requirements for years ahead are enormous, there is a limit to the number of engineering firms that can be effectively supported by the home market. The pace at which industrial development can effectively progress is limited and uncertain and in turn determines the maximum industry that can be supported. The great fluctuations in demand can in part be met by overseas requirements. Such fluctuations often result in the disbanding of technical staff carefully assembled, with consequent loss of valuable experience, not to mention loss of employment. Foreign contracts not only offer the opportunity of retaining such staff intact in some measure, but provide challenging engineering assignments. There is no need to tell members of this Engineering Institute that engineers need the challenge of difficult assignments in order to flourish professionally. Canadian engineers have had more than a full share of difficult tasks within their own country, and have performed remarkable engineering feats that have attracted world wide attention. But such opportunities are limited even in a vast country like Canada, and furthermore must be shared with a growing number of competitors.

A nation like Canada, in full force of development, builds up an inventory of skills and knowledge which in due course leads to pressures for their full utilization. Overseas work can utilize these pressures and insure use of engineering developments that might otherwise go unused.

Although the advantages to the country as a whole are, of course, obvious, the contribution made by each segment of the industry may be briefly mentioned. The consulting engineer* is receiving increased recognition for his important role as an ambassador for his country. He can do much to influence within the limits of his professional status and the economics of the situation, the choice of equipment and materials. He is naturally most familiar with the performance and characteristics of products from his own country. All other factors being equal he will tend to favour a product of which he has knowledge. The contractor who submits an all inclusive bid will, of course, want to remain competitive and will not necessarily select home equipment, but he will nevertheless tend to favour the home supplier whose products he knows well. The manufacturer can well regard his exported equipment as standing evidence to local populations abroad of his country's ability to supply equipment of quality, not to mention the benefit he himself can expect from possible re-orders, as is so often the practice of satisfied users of special equipment.

What Are The Obstacles

One of the major obstacles to the development of foreign opportunities is the need to spend considerable time and money on travel and investigations, in search of assignments. There are ways of dealing with this problem, as discussed below, but there is no minimizing the difficulty for the small firm. Nevertheless, some have found that once an assignment has been secured, other assignments are more easily obtained. Of course, the difficulty will vary with the type of firm. Consulting engineers need to do more on-the-spot investigating than do manufacturers. Contractors are faced with substantially the same problems as the consultant, but a contracting firm may have more extensive resources and a larger stake than the consultant.

Other difficulties include a lack of familiarity with local business methods, taxation legislation and the absence of reliable data upon which to base cost estimates. Payment conditions may require the extension of short or long term credit, acceptance of local currencies or of commodities on a barter basis. There are additional risks that arise from political instability. These difficulties are not without solution, as explained further on, but they do add to the complexity of foreign dealings and entail expenditure of time and money, often with no immediate returns in sight.

Other difficulties arise from within the exporting country. Some of these are intangible but very real. For instance, some manufacturers conclude *a priori* that their prices will not meet foreign competition, forgetting that price may not be the main competitive factor or that the foreign standards may permit the utilization of lighter construction. Some consulting engineers continue to quote terms that are unrealistic in the light of local business practices. Prospective exporters need to examine their own views before reaching conclusions as to their ability to compete abroad.

Let us take the situation in Canada for example. The matter of high Canadian costs needs to be examined in the light of hard realities. High wages tend to lead to higher cost products and services and Canadian exporters are at times priced out of the market. However, our tenders can be encouragingly competitive when the trouble is taken to "sharpen pencils", to use a term of the trade. Many Canadian exporters of engineering products and services are displaying ingenuity in finding solutions. These solutions are based on such devices as the use of alternative materials that foreign competition is not using, combinations of equipment from various countries ensuring that at least a portion of the contract will go to Canadian suppliers, and the establishment of foreign partnerships

* The role of the consulting engineer in foreign trade was the object of a special study in France. The report published in L'Usine Nouvelle for January 1958 contains an interesting analysis of engineering as an export commodity. (See bibliography)

leading to joint submissions. Many of these tenders are based on the realization that price is not always the main factor in competition. Ability to deliver at a given time and to keep delivery promises, technical superiority, availability of spare parts and service, are all factors that the buyer takes into account when making a choice. These are almost self-evident truths, but it is remarkable how often prospective exporters will let stand in the way, obstacles that can be overcome.

Solutions To Overseas Problems

While there are many ways of dealing with export problems, there is an approach which holds so much promise that it is singled out for special mention. This involves a group effort by several firms cooperating in all phases of the operation from the initial steps towards finding work to the final execution of a contract. The group effort, as exemplified by the consortium, offers the advantage of pooled resources and should be an attractive proposition for both large and small firms. For the latter, it may provide the only effective means of prospecting for foreign work, as many small firms do not have the financial resources to engage in foreign travel that at times is so necessary to negotiate contracts involving highly developed products or services. Larger firms will also benefit, especially when large projects are involved. A large-scale project is normally beyond the abilities of a single firm and requires a variety of services and products. The cooperative effort offers the attractive possibility of liaison with foreign groups located either in the importing country or supplier countries, on the principle that half a loaf is better than none at all.

The Consortium

The consortium is typical of the cooperative effort. Consortia are either *ad hoc*—set up for the occasion, or a permanent arrangement between firms. The consortium has for origin the demand for contractors to undertake schemes beyond the technical and financial capabilities of a single firm.

The objective of the *ad hoc* organization is usually to tender or negotiate a specific project and to undertake that project if the tender or negotiations are successful. The objective of the more permanent type of organization is to provide a common service to its member firms to explore contract possibilities, or to put it in other terms, to market its joint services and products. There are, of course, variations. Among the consortium type organizations there are associations whose purpose is mainly the marketing of equipment and, if required, arranging for group combinations to supply products and services.

An outstanding example of the consortium set up for a specific purpose is ISCON, the Indian Steel Works Construction Company Limited, which came into being in 1955 as a consortium of thirteen British manufacturing, electrical, structural and civil engineering firms to deliver in India in a package deal a 1¼ million ingot-tons per year steel plant. ISCON was set up mainly through the activities of MEECO, the Metallurgical Equipment Export Company Limited, a permanent-type consortium formed in 1945 and composed of six firms. Among more recent groups are the nuclear power consortia established in the United Kingdom in connection with the construction of reactors, and other nuclear plant. Another example of the ad hoc consortium is RUSTYFIA a group of British companies formed to build a tire factory at Dnepropetrovsk in the USSR.

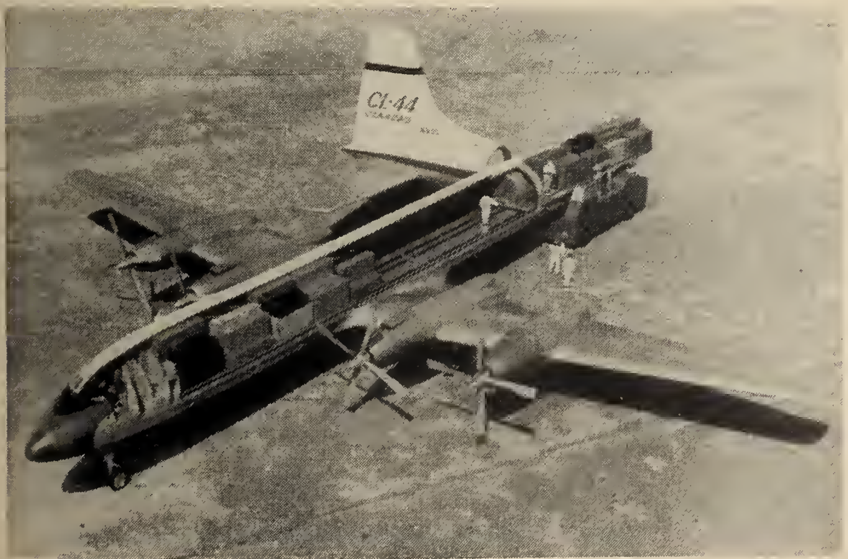
For examples of the permanent type consortium one need not go further than right here in Canada. A purely Canadian firm is Canadian Overseas Projects Limited, which constructed the Maple Leaf Cement plant in Pakistan under the auspices of the Colombo Plan. BEPCO, British Electrical Plant Company (Canada), formed in 1933 for the sale and servicing of equipment imported into Canada from the United Kingdom, is engaged in manufacturing activities of its own in Canada.

Group One Limited, a British organization which includes some foreign firms, is a typical permanent organization that might well serve as an example for Canadian firms to follow. Group One's purpose is to bring large scale engineering projects to the attention of its members and to arrange where required the formation of consortia. The work is carried out by the consortia and the administration normally remains with Group One. The work is mainly confined to member firms, but there is some flexibility as the Group always attempts to bring in a local firm. This is often a requirement in some countries today and is very desirable from a practical point of view for the prestige that it can bring.

Consortia are to be found in all countries of the world interested in overseas work. In France, France-Technique is an association of eleven French companies established for the purpose of developing contracts for member-firms. It arranges for the formation of consortia of French firms, members or not, either alone or in partnership with non-French firms. This group furnishes another excellent example that could be followed. ICOFRANCE, a French group is not strictly a consortium but rather an association of French consulting engineers interested in overseas projects. In Italy, ITALCONSULT, Societe Generale per Progettazioni Consulenze e Pertecipazioni, was organized to undertake consulting engineering assignments as well as to take on the responsibility for the actual carrying out of works. Associated companies comprise IMPRESIT—Imprese Italiane allo Estere and ELECTRO-CONSULT which carry out respectively construction works and electrical installations.

Netherlands Engineering Consultants, NEDECO, is another cooperative unit that pools the efforts of con-

Fig. 2. A four engine, jet-prop long range transport plane, built in Canada, already has a market in the United States.



sulting engineering bureaux with the assistance of other experts and technical or scientific organizations in the Netherlands.

If the cooperative effort has been treated at length, it is to stress the potential of such an approach in providing a solution to some of the problems that confront exporters of engineering equipment and services. In Canada especially, where firms on the whole are comparatively small, but have so much to offer countries in process of development, the formation of consortia or associations especially aimed at engineering exports, would appear to offer attractive possibilities.

Fig. 3. Log bundles being hoisted from the river at the Khulna, East Pakistan pulp and paper mill, designed and constructed by Canadian firms.

Consortia and Consultants

Before leaving the subject of consortia, it seems appropriate to consider the part the consulting engineer may play in such associations. As consortia by their very nature, at least in their original form, are likely to be involved in turn-key projects, the consulting engineer associated with a consortium may find himself in an untenable position, from the professional point of view. There are, however, ways that the consulting engineer can deal with this situation. He may be engaged as consultant to the contractor on a fee basis and not as a participant in profits. Another solution that holds some promise and seems to be gaining in favour is the consultant acting as an adviser to the project sponsor and "vetting" the designs submitted by the consortium members. Such an arrangement has apparently met with some success in the case of the ISCON contract with the Indian Government's steel mill. A Canadian consulting engineering firm has recently had this type of assignment for an industrial project in the Middle East.

On a broader plane, an arrangement of some interest is the agreement between the Export Group for the Constructional Industries and the Association of Consulting Engineers in the United Kingdom. A consulting engineer can work for a contractor or group of contractors in preparing designs for the works and giving technical advice. This can be considered a significant development, as the Association of Consulting Engineers in the United Kingdom, as is our own, is well known for the high professional standards of its members. This and other developments would seem to indicate that the professional engineering groups recognize that practical steps must be taken to allow the professional engineer to take an increasingly effective part in the highly competitive international scene. There has even been the suggestion in the United Kingdom that the consulting engineers would view with favour the formation of a government-supported British equivalent to the Continental organizations backed by finance houses and in some instances governments. Selected group members proceed to the site, make a project report and then offer consulting services for the scheme.

The Foreign Trade Service

It seems appropriate at this juncture to discuss the services available from the Department of Trade and Commerce. The facilities in Ottawa and abroad provide an example of a cooperative effort maintained by Canadian companies, as taxpayers. The Foreign Trade Service is in fact, a listening post for all types of engineering opportunities abroad. It is a clearing house and assists Canadian firms find solutions to export problems. The Engineering and Equipment Division assists consulting engineering firms, equipment manufacturers and contractors in obtaining a share of foreign contracts and orders. Information can be obtained from the department on the services available from this and other divisions. It may be useful, however, to point out here that Canada maintains trade commissioners in over fifty trading centres throughout the world whose services are available on request. Direct communication with our posts abroad makes for an efficiency for which our Trade Commissioner Service is well known. This procedure is not found in many other countries. Personnel at headquarters offices, maintain a close personal relationship with firms interested in exporting. This makes for a most useful triangular arrangement involving exporters, trade officers overseas and headquarters.

The Department utilizes several devices for export trade promotion. One of these is the fortnightly publication "Foreign Trade", which has of late devoted increasing attention to subjects of interest to engineering firms. A recent issue features nuclear engineering in export trade and contains an account of the Canadian trade exhibit sponsored by the Department at the AtomFair in Cleveland last April. Trade exhibits are used by the department for promoting trade. A Canadian display featuring the products and services of thirty firms for engineering designers was part of the Design Engineering Show held in May in Philadelphia. Through this means it is hoped to gain increased recognition for Canadian engineering products in the United States and other countries.

The difficulty in keeping in touch with developments abroad and interpreting local conditions can be partly met by the appointment of a local representative, or by a partnership arrangement. The selection of the agent is naturally most important. The trade commissioner can readily assist in this direction, and give advice on local business practices, taxation, etc. In many countries it may not be possible to find suitably qualified persons, especially if highly technical products or services are involved. In such instances, it will likely be necessary to travel to the country in question to look into matters at first hand. A local partnership arrangement or joint venture is effective, when sufficiently competent partners can be found. A knowledge of local conditions is obtained that might otherwise be difficult to secure, and valuable introductions to locally prominent persons come without too much difficulty, to say nothing of the local good relations such an association can bring.

Conditions of Contract

Because practices differ in different countries, there is sometimes some difficulty in drawing up a satisfactory contract especially for the larger type of project involving extensive works and where the call for tenders is on an international basis. To cope with this condition a model contract document was issued last year, entitled "International Conditions of Contract for Civil Engineering Works". It is the result of many years joint effort by the Federation Internationale des Ingenieurs Conseils (FIDIC) and the Federation Internationale du Batiment et des Travaux Publics (FIBTP). It has the endorsement of member organizations in twenty-six countries includi:ng Canada (Canadian Construction Association). The relationship between client, consulting engineer and contractor is defined in precise terms. "The Engineer" is held responsible for supervision of the work and for adjudicating on claims. A clause provides for arbitration by the Board of Arbitration of the International Chamber of Commerce, in the event of dispute.

Financing

Many foreign purchasers of engineering services and equipment insist on credit terms varying from a few years to five, seven or more. Some obtain such terms and, in addition, no payments on principal for a number of years and at low rates of interest. Such terms are often made possible through the backing of financial houses who have an ownership interest in the suppliers, or credit may have been advanced by a government supported development lending institution.

In Canada, it has been possible for a number of firms to secure chartered bank loans running into millions of dollars through their own credit standing, in combination with an insurance policy issued by the Export Credits Insurance Corporation (ECIC) covering the foreign risk. ECIC is a Crown agency, which will consider issuing an insurance policy covering foreign risks of non-payment for eighty-five per cent of the amount of the contract for periods amounting to several years for assisting the financing of substantial contracts. ECIC is a member of the Union des Assureurs de Credit Internationaux de Berne (Berne Union), an organization that provides a forum for export credit insurers from eighteen nations. Changes in the legislation affecting export credits insurance to provide additional facilities for assisting the financing of large contracts were indicated in Parliament in the Throne Speech.[1] Export credit insurance is available for exporters of services, including consulting engineers and contractors.

A private bill is before Parliament for the establishment of a company to be called Export Finance Corporation of Canada Limited.[2] It is understood that this private Corporation is designed to make available loans to exporters or foreign buyers.

When dollars are not available, it may be necessary for a firm to consider accepting commodities or currency other than dollars. Barter dealing or negotiating currencies is not a substantial part of the experience of Canadian engineering firms, though some are known to have accepted sugar, oranges, and other commodities. A consortium with its vaster possibilities, especially if it has foreign connections, may be in a position to consider barter deals and accept soft currencies. Bartering is the oldest form of trade and in the mind of some exporters of engineering commodities offers the possibility of doing business that would otherwise be impossible.

Though long term financing and soft currencies present problems, there are a number of interesting projects for which financing and dollars are already provided. These are the projects financed by the International Bank, International Finance Corporation, U.S. Development Loan Fund and U.S. International Cooperation Administration and other organizations that provide financing for approved projects in countries requiring economic assistance.

The investor often determines the source of supply for services and equipment. Close association with initiators of projects abroad will provide an engineering firm with a greater share of export markets. It is well known that the engineering for projects tends to come from the country of origin of the project initiator or investor. An example of an effort in this direction in Canada is to be found in the Indian-Canadian Corporation proposed by a prominent Canadian consulting engineer. The proposed Corporation would involve Indian investment for local costs and Canadian investment in equipment and engineering services for basic industries in India.

While price, delivery and financing are important factors, it should not be lost sight of that competitive advantage in many cases depends upon technological excellence. Highly developed products or complex works are dependent upon ideas and know-how developed through years of experience and systematic research. To remain ahead in foreign engineering markets, firms need constantly to develop products and services leading to new lines. These can be introduced at the right time to meet competing products as they catch up.

What Are The Opportunities

Almost everyone is aware of the extensive programmes for economic development throughout the world, especially in countries seeking higher levels of economic development. These programmes offer opportunities to consulting engineers, contractors and manufacturers. At the initial stages, surveys and services of all kinds are required, including feasibility studies, resources surveys, aerial surveys, exploration drilling and helicopter services. At later stages, actual design studies and construction supervision, construction of works, installation and supply of equipment and in some instances the start-up of operations. Projects include docks, harbours, railways, bridges, roads, airports, dams, irrigation schemes, pipelines, oil refineries, chemical plants, as well as factory buildings, housing, hospitals, hotels and universities.

Projects financed or proposed to be financed by the International Bank require consulting engineers for engineering and economic feasibility studies. The consulting engineer is selected and retained by the borrower, but must meet with the approval of the Bank. It is, therefore, important that consultants interested in international work be known to the Bank. This can be done by depositing with the Bank a description of past work done and professional qualifications of staff. In the case of Canadian firms, this can be facilitated through the Minister (Commercial) of the Canadian Embassy in Washington, D.C.

It is of interest to note that, at the end of 1958, the International Bank had made two hundred and nineteen loans in the twelve years of its existence totaling some $4 billion. In the same period, imports from Canada by borrowing countries with the proceeds of the Bank loans amounted to about $121 million of approximately $2.4 billion spent abroad, or just about 5%.

1) Legislation eventually enacted in 1959 provides for export credit guarantees to be made directly to lenders thus providing a broader source for funds.
2) Export Finance Corporation was established in 1959 as a private company by Act of Parliament. The authorized capitalization is $50 million, with lending power of $500 million.

There are large scale projects under the NATO Infrastructure Programme for the construction of airports, pipelines, telecommunication systems, for which tenders have been called internationally by host countries. Some of these projects have proved to be of interest to Canadian suppliers, while others have been of such nature as to be of interest only to the host country or at least to close-by European countries.

Though perhaps not of as direct interest to Canadian suppliers, mention should be made of the activities of the Commonwealth Development Finance Company, a public United Kingdom company established in 1953 following the Commonwealth Economic Conference in 1952 whose share capital is subscribed by private interests and the Bank of England. The main objects of CDFC are to provide or procure financial facilities for the development of the natural and other resources of any part of the Commonwealth, particularly those which may benefit the balance of payments of the sterling area. According to circumstances it may make a direct loan, take up debenture stock or subscribe to equity capital. CDFC cooperated with the International Bank in making an investment of £3 million in the Kariba Hydroelectric project in Rhodesia. It helped finance for the Tasman Pulp and Paper Company, a pulp and paper plant in New Zealand in the amount of £3 million. It also has a financial commitment in Algom Uranium Mines Limited for development of a uranium mine in the Blind River area of Northern Ontario at £1,350,000.

The International Cooperation Administration (ICA) and the Development Loan Fund are two United States international activities that are of interest as many of the tenders are on a world wide basis. ICA was created in 1955 as the United States agency responsible for the administration of economic aid given by the United States to other countries. ICA aid may be in the nature of either a grant or a loan. Where the aid is a grant, purchasing is done by the recipient country or procured by ICA by public tender generally on an international basis. Consultants are selected from a list of United States firms in Washington. When the aid is a loan the calls for tender are generally made by the recipient country.

The Development Loan Fund was established by the United States in 1957 as a means of providing for long term development. Loans are made either to governments or to private firms in recipient countries for long terms (up to forty years) and a period may be allowed before repayment commences, interest only being due in the meantime. They are for use primarily to purchase industrial plant and capital goods and pay for highly skilled labour and technical advice on installation. It would appear that, in general, calls for tender in connection with projects financed by the Development Loan Fund are on a world wide basis.*

Canadian Engineering Abroad

It may well be asked whether Canadian engineering firms are fully participating in overseas projects. As a net importer of engineering services and equipment, Canada has not generally been regarded as a major supplier but in the last several years there has been a noticeable upward trend in interest and in actual participation. This has been due no doubt to the high activity that has prevailed at home. Firms were kept so occupied that they were relatively uninterested in overseas work until the recent pause in the economy aroused new interest. Firms were not only driven by the need to find new outlets but they found themselves equipped with extensive inventories of skills and know-how of a kind that is needed in many developing countries.

Canadian firms are today to be found in Asia, Africa, Latin America and the Middle East involved in exporting such engineering commodities as aerial surveying, consulting engineering, construction contracting, telecommunications networks, equipment of various types including turbines, generators, aircraft, special vehicles and nuclear products. This is in addition to the exports under the Colombo Plan of large scale dam engineering, cement plants, fish plants, which provide valuable foreign experience and may lead firms to seek work under the conditions of competitive trade.

Canadians are naturally finding that they are most wanted for services and products which they know well, such as aerial surveying, hydroelectric engineering and pulp and paper consulting engineering. Aerial survey firms find that not only are they able to provide services equal in quality to any offered anywhere, but are able to do so at competitive prices. The warmer climates in which many underdeveloped countries are located offer an opportunity to use equipment that would otherwise not be used because of Canada's winter weather. Canadian aerial survey firms are to be found everywhere in the world.

Our pulp and paper consultants are active in Spain, Portugal, Brazil, Mexico, Pakistan, Norway, Sweden, Finland, Tunisia and Egypt. Foreign projects offer these firms the opportunity not only of making available highly developed knowledge, but the demand comes at a time when Canadian programmes in the paper industry are somewhat curtailed.

Canadian equipment is enjoying some favour abroad. Hydroelectric turbines have had substantial markets for many years. Aircraft are being exported in increasing quantities as their quality and special characteristics become better known. Especially built machine tools and accessories are being sold in the United States under highly competitive conditions. All-terrain vehicles developed in Canada are to be found in many countries of the world.

If a general conclusion can be drawn, it is that many of the difficulties encountered by engineering firms wishing to export are by no means insurmountable, if the right approach is taken. The rewards can be great — to the engineer in his professional capacity and to the firm as a business enterprise.

* Policy changes effected late in 1959 limit procurement normally to United States sources.

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The Seventy-Fourth Annual General Meeting of the Engineering Institute of Canada will be held on Wednesday, May 25, 1960, at the Royal Alexandra Hotel, Winnipeg, Manitoba, between the hours of 10:00 a.m. and Noon. This meeting will receive the report of the official auditors, the Annual Report of Council, Committees, Representatives, and Branches, and such other business as may come before the meeting.

Garnet T. Page, M.E.I.C.
General Secretary

DISCUSSION

of Technical Papers and Other Articles

RIVER CONTROL IN THE INTERNATIONAL SECTION ST. LAWRENCE POWER PROJECT

Mr. K. A. Henry, Jr.E.I.C.
River Control Engineer,
The Hydro-Electric Power Commission of Ontario.
The Engineering Journal, 1960, January, p. 63

Discussion by Mr. Geo. H. Kohl, M.E.I.C.

Mr. Henry is to be commended for the presentation of his paper which describes clearly and concisely an important and delicate operation carried out over a 4 yr. period.

The paper describes the procedure so adequately that very little comment is required and these remarks will be confined to two items, one concerning the conditions for river control set up by the Government authorities and the other referring briefly to negative seiches recorded in the past.

The Order of Approval covering construction and operation of the power works issued in 1952 by the International Joint Commission stated that "the works shall be so planned, located, constructed, maintained and operated as not to conflict with or restrain use of the waters . . . for domestic and sanitary purposes, and . . . navigation" and also "in such manner as to safeguard the rights . . . of others engaged or to be engaged in the development of power below the International Rapids Section". The latter, of course, refers to existing development of Quebec Hydro at Beauharnois and the possible future development of Lachine Rapids by the same entity.

Two Boards were also set up. One, The St. Lawrence River Joint Board of Engineers reporting to the Government through the Minister of Transport is an approval and supervisory Board to act during construction, and the other The International St. Lawrence River Board of Control reporting to the International Joint Commission and charged with responsibility of overseeing and reporting on River Control operation when the present control "as in nature" is changed to an artificial method of regulation following a method already recommended to the two Governments by the International Joint Commission. During the construction period these two Boards work in close co-operation with regard to all matters affecting levels and flows.

The Joint Board at an early date gave general approval to a plan of control prepared by the two Power Entities, Ontario Hydro in Canada and the Power Authority of the State of New York in the United States, stipulating, however, that the River Control Engineer must have ample, direct authority in order to permit him to carry out his heavy responsibilities. It also directed that the control must be so carried out as to maintain natural river discharges at all times, with minor variations under certain critical conditions which would enable him to control seiches in the most expeditious manner and to provide for filling of the power pool. Under these conditions of discharge there could be no hurt to downstream power entities and no change in the natural levels of Lake Ontario, Lake St. Louis and Montreal Harbour.

The Power Entities were also directed to maintain river levels necessary for navigation in the International Rapids Section particularly at the entrances to the Iroquois, Morrisburg, Farran's Point and Cornwall Canals. Minimum levels required 14'9" on lock sills and maximum levels should not be such as to overtop the canal gates or endanger the embankments. This latter directive required very careful scheduling as the channels were excavated and as the cofferdams were placed and removed. Above the Iroquois Dam, the old canal embankment had to be raised and riprapped prior to the opening of the Galop Cut. At Lock 21 opposite the big cut at Long Sault Island, the river discharge at the time of the diversion was such that the river level could be raised 3 ft. above the natural level without interfering with lock operation eliminating considerable remedial work which otherwise would have been necessary.

During filling of the power pool in the early part of July 1958, the conditions in Montreal Harbour were such that the downstream flow could safely be reduced below the natural discharge. Advantage was taken of this situation to speed up the filling of the pool and so reduce the delay to navigation involved in transferring shipping from the old 14 ft. canals on the Canadian side to the new locks at Massena and Iroquois, but this was only possible by the wholehearted co-operation of Quebec Hydro.

In spite of, and possibly because of these rigid requirements, the control of the river has been maintained substantially in the state of nature with no interruption to 14 ft. navigation due to changes of water levels. Mr. Henry and his associates have performed their arduous task with complete satisfaction.

With regard to the sudden changes in river levels caused by combined wind and barometric pressure, that is a seiche, a study was made early in 1955 to determine what allowance

(Continued on page 126)

TABLE I

SEICHES OCCURRING DURING THE NAVIGATION SEASON

Gauge	Kingston	Lock 27	Lock 25
Location	on L. Ontario	Above Galop Is.	At Iroquois
No. of Occurrences	383	294	334
Years of Record	1909/54	1922/54	1917/54
% of Total Occurrences	NEGATIVE DEVIATIONS IN FEET		
20%	0.6 or greater	1.12 or greater	1.22 or greater
10%	0.75 " "	1.35 " "	1.50 " "
Max.	1.23	3.02	4.14

ABSTRACTS

OF 1960 ANNUAL GENERAL MEETING PAPERS

Design and Erection of Structural Steel for the Thompson Project
W. H. Bender

The process and type of equipment used in construction of the auxiliary buildings, concentrator, headframe, smelter and refinery at International Nickel's far northern Moak Lake, Mystery Lake development demonstrate the close connection between plant and structure in an industrial project of this nature. Design procedures were in large part determined by two rules — simplicity and standardization. Anti-corrosion treatment was used in construction of the refinery. Discussion of: various aspects of steel erection — target tonnages, equipment, manpower and weather difficulties; erection of the hoist house steel atop a 220 ft. headframe; erection of two 60-ton heavy duty cranes; placing of four rotary converters in the smelter. Concludes with comments on advanced planning for this large-scale project.

The Dunvegan Suspension Bridge
T. Lamb, M.E.I.C., and *R. N. McManus*, M.E.I.C.

Conditions of local topography, existing approach roads and other factors led to the choice of a skew crossing just upstream from the present ferry crossing on the Peace River near Dunvegan, Alberta. Investigations showed that the proposed site was underlain by a glaciated shale 25 to 65 ft. below water level, which in turn was covered with a layer of river-deposited gravel of from 10 ft. on the south shore to 70 ft. on the north. Recommended that all pier bases be carried at least 80 ft. below high water and through all river-deposited material. A suspension bridge was selected which could be supported by two piers, only one of which would have to go through the deep gravel. Final design of the foundation for the north pier was a three-cell reinforced concrete open caisson. The south pier required only a conventional cofferdam. Superstructure design followed A.A.S.H.O. specifications as far as possible. Towers were hinged at the base and tapered both ways from a point of maximum size

A New Canadian Structural Test Installation
W. R. Schriever and *W. G. Plewes*, JR.E.I.C.

An installation for structural tests was recently constructed in the main laboratory of NRC's Division of Building Research in Ottawa to provide a convenient and standard facility for loading tests on a variety of structural components. Three main parts: a strong reinforced concrete test floor, a set of steel frames to be assembled around the test object and anchored to the floor, and portable hydraulic jacks for application of loads. Test floor is constructed to resist upward forces, using weight of underlying bedrock through special pretensioned rock anchors. Structural steel reaction frames, connected to the slab and to each other by torqued high-strength steel bolts, provide maximum rigidity. Portable jacks, varying in capacity from 2½ to 50 tons, are suitable for both static and dynamic testing. Design and construction of the installation are described with reference to similar projects in other countries.

The Structural Behaviour of Highway Bridge Decks
S. D. Lash, M.E.I.C., and *B. B. Hope*

Theoretical studies included the problems of composite action, load distribution and research questions. From full-scale tests on three bridges information is recorded on ultimate strength, loads transmitted longitudinally by floors, composite action on timber floor and concrete floor, load distribution, deflections, effects of concentrated loads applied between stringers, and a comparison of timber and concrete floors. Conclusions concern safe capacity of bridge floors under static loads and methods of straightening existing bridges.

Construction of the Warsak Hydro-Electric and Irrigation Project, West Pakistan, A Canadian Colombo Plan Undertaking
C. C. Kingsmill, M.E.I.C.

The project aims to produce power and irrigation and to train Pakistani workers in modern construction methods. Costs have been divided between Canada and Pakistan. The paper describes geography, climate and regimen of the river as well as availability of construction materials, power and food facilities. Construction schedule and job cost estimate made with scant knowledge of conditions and unknown requirement of experienced personnel from Canada. Special problems: religion, language and culture, methods of local recruitment and labour turnover. Efforts made toward standardization and repair facilities provided. Difficulty in bringing skilled labour from other parts of country. Concentration of work on dam where narrow gorge limited working area. Cofferdam construction to stand overtopping during floods. Tunnels included diversion, power, penstock and irrigation.

Engineering Computation in the Chemical Industry Using Digital and Analog Computers
V. J. Bakanowski and *R. N. Boyd*

Electronic analog and digital computers produce better and more economic answers through the use of more analytical methods of solution. This paper describes the application of both types of computers to engineering problems in the chemical industry. Reasons for a shift from empirical to analytical technology. Discussion of: basic characteristics of the computers; history of development; criteria for determining the types of problems best solved on either computer. Case studies of computer application: IBM type 650 used to analyse the stresses in fixed head shell and tube heat exchanges from thermal and pressure loading; 120 amplifier Pace analog computer used to simulate part of a chemical process for analysis of the dynamic response of the system of process vessels, connecting piping and instruments.

The Principles of Automatic Control
Arthur Porter

Control system technology has undergone a profound change during the past two decades due to application of analog and digital computers, increased reliability and efficiency of electronic components, evolution of a comprehensive theory of linear systems, and the recognition that certain classes of non-linear control systems can be designed scientifically. Control problems now formulated on the basis of system optimization. Re-evaluation of the basic principles of automatic control. System optimization is optimum utilization of information. It necessitates feedback processes. First-order feedback loops are usually inadequate to optimize complex processes, thus second-order and a hierarchy of control loops are perhaps required. Coding is a prerequisite for information classification and leads to the concept of pattern recognition. Discussion of: associated problems of decision-making and logical goal-seeking; requirements of automatic controls based on the principle of self-organization.

Process Control

PROCESS CONTROL is a term that is rather loosely applied nowadays. This article will consider the control of vapour-phase and liquid-phase continuous processes such as are commonly in use in the petroleum and chemical industries.

Why are these processes controlled? How? What future developments are likely? These are some of the questions to which answers will be attempted, though they must necessarily be brief. A few examples of advanced techniques now in use may serve as a link between current general practice and some conjecture about the ultimate goals of the processing industries in the field of control.

Why are Petroleum and Chemical Processes Controlled?

It may seem rather elementary to ask an engineer why control is necessary in the process industries. Not too long ago the answer might also have been fairly elementary, but now it is becoming ever more complex.

In the petroleum industry, for example, the refining of crude oil was originally largely a simple distillation operation. Little attempt was made to get more than a few useful fractions until the demand for gasolines as motor fuel became widespread. Control was manual, and consisted mainly of operating the furnace at the correct rate. Even recording instruments were few, and there must be many who can remember the convenient, though not too accurate,, method of determining temperature by spitting on a hot line.

From simple distillation the refining of petroleum has developed to include many physical and chemical processes operated over a wide range of temperatures, pressures, rates of flow, and other variable conditions. Often, these processes are carried out continuously in a series of interconnected process units, the aim being to convert the crude oil or other raw material into certain desired end-products. In between the start and end points several process streams divide, undergo individual treatment under various conditions, may be further divided or recombined at different stages, recycled, extracted, and so on. All these procedures take place simultaneously, and departure from correct conditions in any one process will affect all the others, possibly to the extent of causing a complete shut-down of the installation.

The unplanned shut-down of a refinery or chemical plant is a very expensive and undesirable event. A complete shutdown is also more likely with the present trend to integration of entire plant operations and the elimination of intermediate product shortage facilities, which were necessary when process units within a plant operated independently or in small groups. Then, if one unit went out of control and had to be shut down, the other units could continue to operate and either send their products to, or draw their feedstock from, intermediate storage.

To compete economically, the process industries must reduce their installation and operation costs. There are too many factors involved for a discussion here of how this can be done, but control and automation of processes are among the leading methods for achieving greater efficiency. Obviously a completely integrated plant can be more efficient and less costly to build and operate than one that requires extra intermediate product storage and handling facilities, and also involves additional energy needs for reheating and recirculating these intermediates. To achieve this complete integration, and to keep individual units and hence the whole plant working most efficiently, reliable control of process variables is essential.

What is Controlled, and How?

In the process industries considered here, the factors most commonly measured and controlled are temperature, pressure, and flow-rates of process streams, and liquid levels. Advanced control also considers the composition of process streams, the activity of catalysts, and so on by continuous analytical methods.

Temperature. Process temperatures may be measured by thermocouples, resistance-bulbs or bimetallic dial thermometers. Remote indicators and controllers may use filled-bulb force-balance pneumatic transmitters, up to about 800°F., or electronic null-balance instruments. Electric-pneumatic transducers are used for high-temperature control points above the limit for pneumatic transmitters. For control work, transmitters may have rate action to overcome measurement and transmission lags.

Pressure. The main instruments used to measure pressure are bourdon tubes, bellows, and diaphragms. For control applications, force-balance transmitters are used with bellows or diaphragm.

Flow and Level. Differential pressure manometers, area-meters, and positive-displacement meters are used to measure flow. Level measurement, also frequently necessary in the processing industries, is usually by gauge-glass, float and tape, float-actuated, and differential pressure. The first two are used for local level indication, though float-and-tape indication (e.g., in large storage tanks) may be used with a transmitter for remote indication or recording. Ball float instruments are used for narrow-range level control or level alarm switches, displacer instruments are used in more critical applications. Differential-pressure instruments may be used for local control (deflection bellows type manometers with integral pneumatic control) or for remote indication and control (transmission from force-balance and diaphragm-type manometers).

Transmitters and Receivers. Pneumatic or electric transmission is used between measuring and control instruments and, for example, a control centre. Force-balance pneumatic transmitters are largely used; indicator or recorder types of receiver may be round-dial, miniature, or large-case multipoint recorders, according to the application required. Electronic transmitters use a measuring element to produce an electronic signal proportional to the process variable; the electronic receiver is often a miniature control station mounted on a control board, separate indication being provided by a dial voltmeter or ammeter.

Controllers. Pneumatic control is widely used and economical and convenient, though it has certain limitations. Controllers may be mounted in the field (e.g., valve-mounted for flow-control) or on the control board, depending to some extent on the distances involved. The all-electronic control loop is used when transmission distance exceeds a useful limit for pneumatic control (of the order of 500 feet between, say, control valve and controller). The great advantage of electronic control is the reduction of control time lag compared with pneumatic systems, and the great flexibility of system design possible, particularly when considering advanced control involving computer applications.

Process-stream Data

The foregoing outline deals with some of the methods used to get data about process variables, which may be used for record or control. The instruments involved and the principles used are now well-tried and generally familiar to many engineers. A more detailed description of particular instruments and applications is not possible here.

The continuing advancement of the efficiency of processing industries, as far as it can be achieved by control methods, depends on the production of improved instruments and the extension of the information these instruments can provide. The optimum control, within specified limits, of the variables dealt with above (temperature, pressure, flow, and level) is no longer considered the ultimate goal of the processer.

Not only the physical variables, but also certain chemical factors are critical in the maintenance of optimum conditions in a processing plant. Many chemical reactions and equilibria are involved in an integrated series of processes, and in order to know what is happening it is necessary to keep track of key constituents of the process streams. The traditional method of periodic laboratory analysis only confirmed that the physical controls were resulting in a suitable product—or indicated too late that something was amiss.

For optimum control, the processer must know of any departures from ideal stream conditions, and he must know this as soon as possible so that the necessary corrections can be applied before conditions deteriorate beyond acceptable limits. Continuous-stream monitors are now available, and are being further developed, to give the operator essential product data such as end point, initial boiling point, viscosity, vapour pressure, flash point, colour. Gas chromatography enables continuous analyses of stream samples to be made.

At present, the data from such monitor installations are largely being used for manual adjustments to operting conditions, but the ultimate use of monitors will be in a control loop to reset control points on standard controllers.

Control by Computer

Assuming that the ideal process dynamics are known a given plant can be kept operating continuously at optimum efficiency only if measuring instruments can provide sufficient data practically instantaneously. A computer system is then necessary to digest all the information provided and to apply necessary corrections before appreciable changes can occur.

Several computer-control applications are already operating, and a wide development in this field may be expected. Initially, the most activity will probably be found in the application of analog units to individual sections or units of processes.

In the petroleum industries, analog computers are now being used in several ways. One system controls reflux in a fractionating tower to maintain capacity vapour rate; annual savings of some $5000 are estimated from an installation that costs less than $10,000. Another analog computer maintains internal reflux of a fractionator at a constant value. An oil company that has set up a process control research centre will use small portable units as process controllers to determine data on which a permanent installation can be designed; the portable unit can then be used in another application.

Computer systems have been developed for 'optimizing' process conditions. One example is a computer with analog input and output, containing comparison and memory, logic, and output sections, plus checking and indicating sections and various operational controls. The system continually experiments with the process, much as a human operator might, but more quickly and accurately, to determine and then to hold the optimum performance level. Such a unit has been in operation since mid-1958 to control a pilot plant that makes styrene by dehydrogenation of ethyl benzene.

Once all the necessary factors are known, and optimum control of individual processes has been achieved, the next step towards complete automatic control is control of entire processing units by digital computer. The first such fully automated process in the United States has been operating in a Texas refinery since March 1959. A digital computer completely controls a polymer unit which handles some 15-million cu. ft. a day of feed gas, in which significant variations in composition can occur. The digital unit takes information from 110 different sources, including temperatures, pressures, and flow rates on 16 different streams. From the measurements, settings are determined for feed to the unit, recycle and water flow rate, reactor pressure, and catalyst bed outlet temperature. The computer resets the plant control pattern every five minutes, records what it is doing, and gives warning if the operation limits are exceeded. Considerable increase in efficiency of the unit and savings in catalyst used are expected.

A recent survey indicated eight digital computers already available for process control, and three more on the way. The ultimate goal of the completely automated refinery or chemical plant is a vision of the future. Even if it can be achieved, much work remains to be done to consider all the economic factors involved. Much work will be done in the next decade on the development of better measuring instruments and the determination of optimum conditions for individual processes. Then, perhaps, the completely automated processing plant may become a reality.

1951 Graduates - Please Note

According to amended Institute regulations covering Junior membership, 1951 graduates must apply for transfer (by written application form) to the grade of Member during 1960, if they wish to avoid payment of a transfer fee.

The applicable sections are as follows:—

"——— he shall not remain in the class of Junior beyond the end of the tenth year after graduation.

A Junior may be transferred to Member without payment of a transfer fee providing he makes application before the end of the ninth year after graduation ———"

Photo: Columbia River, Frenchman's Cap, B.C.

Canadian Developments

The Columbia River International Joint Commission has published its recommendations for determining and apportioning benefits from cooperative use of the river. Although there is much negotiation still ahead, this is considered a significant step toward the $1 billion hydro-electric development which one day is expected to produce 145 billion kilowatts. The following is the report in its entirety:

"The Governments of the United States and Canada, as a part of their continuing discussions, have agreed to request the International Joint Commission to report specially to the Governments at an early date its recommendations concerning the principles to be applied in determining:

"(a) the benefits which will result from the cooperative use of storage of waters and electrical interconnection within the Columbia River System; and

"(b) the apportionment between the two countries of such benefits more particularly in regard to electrical generation and flood control."

In the preparation of this special report, the Commission utilized as background data all the information available to it on the water resources development needs and possibilities in the Columbia River area. This included the reports of the International Columbia River Engineering Board under the Columbia River Reference, as well as studies of other agencies in both the United States and Canada. A special work group was established to prepare summaries of the available data that would provide a background and orientation and thus facilitate mutual understanding of the situation and conditions under which principles for benefit determination and apportionment would be applied. Also, the Commission aproached the problem of formulating principles within the context and intent of the Boundary Waters Treaty of 1909.

The studies of the International Columbia River Engineering Board, as well as other available information, indicate clearly that there are possibilities for cooperative development in the Columbia Basin that could be of mutual advantage to the two countries.

Accordingly, the Commission was able to approach the problem of formulating principles for benefit determination and apportionment with information on specific projects for cooperative development which would offer advantages to both countries. The Commission was guided by the basic concept that the principles recommended herein should result in an equitable sharing of the benefits attributable to their cooperative undertakings and that these should result in an advantage to each country as compared with alternatives available to that country. The Commission gave consideration to the practical problems that will be encountered in applying the principles to cooperative arrangements between the two countries on specific projects in the Columbia River Basin. This was done to ensure that the principles would be workable but no attempt was made to spell out in the principles the detailed procedures that will necessarily be delineated when cooperative arrangements are entered into. The Commission recognizes that several administrative and legislative actions in each country may be necessary before these details can be worked out.

The principal benefits in the downstream country from cooperative use of storage of waters within the Columbia River System are improvements in hydroelectric power production and prevention of flood damage.

Although other benefits would also be realized from such cooperative use, the outlook at this time is that their value would be so small in comparison to the power and flood control values that formulation of principles for their determination and apportionment would not be warranted. This is not intended to preclude consideration by the two Governments of any benefits, tangible or intangible, which may prove to be significant in the selection of projects or formulation of agreements thereon.

The prospective downstream power benefits are transportable and within reasonable transmission distances of the boundary. With adequate electrical interconnection, it would therefore be feasible to share these benefits in kind, that is, share the power itself rather than its value in money.

The flood control benefits, however, accrue in specific localities and are not transportable. Co-operative use of storage designed to produce such benefits therefore requires recompense in money or by other means. In addition to providing a means for the return to the upstream country of its share of downstream power benefits, electrical interconnection between the power systems in the upstream and downstream countries opens the possibility of significant economies and advantages in the operation of the interconnected systems in both countries through the co-operative use of generation and transmission facilities.

In view of the foregoing, the Commission's recommendations on principles for benefit determination and apportionment are presented herein in three sections, namely, general principles, power principles and flood control principles.

GENERAL PRINCIPLES

SELECTION OF PROJECTS

A necessary step in the development of cooperative arrangements involving sharing of downstream benefits is the selection of the projects to which such arrangements would apply.

In selecting individual projects from among the available alternatives in both countries for comprehensive development of the Columbia River Basin, it would be consistent with customary practice to give first consideration to those projects that are most attractive economically as reflected in the ratio of benefits to costs. It is suggested that this widely accepted principle be followed in international cooperative development of the Columbia River Basin to the extent that it may prove practicable and feasible to do so. If projects are developed successively to meet the growing needs for power production and to provide flood protection, the most efficient projects for those purposes should generally be developed first in order to maximize the net benefits to each country. It is recognized, however, that the results to be obtained from possible cooperative projects in the Columbia River Basin will constitute only a part of the total requirements for water resource development and use in the affected regions in both countries.

Therefore application of the principle will necessarily be subject to the sovereign responsibilities in each country with respect to many vital and important national interests which must be taken into account in utilizing the water resources in each country.

The Commission therefore recommends the following general principles:

GENERAL PRINCIPLE NO. 1

Cooperative development of the water resources of the Columbia River Basin, designed to provide optimum benefits to each country, requires that the storage facilities and downstream power production facilities proposed by the respective countries will, to the extent it is practicable and feasible to do so, be added in the order of the most favorable benefit-cost ratio, with due consideration of factors not reflected in the ratio.

DISCUSSION OF GENERAL PRINCIPLE NO. 1

It is intended in the application of this principle that benefits and costs of the projects given consideration in either country would be determined on the basis of the same or comparable evaluation standards, including such factors as the nature and extent of the benefits to be considered, the evaluation of such benefits, the determination of the initial investment and the computation of the annual costs.

The phrase "to the extent that it is practicable and feasible to do so" is included in recognition of the fact that it will not always be possible to adopt a project wholly on the basis of its benefit-cost ratio as compared to other projects in the river basin.

There may be important non-monetary factors, not reflected in the benefit-cost ratio, which may require consideration and which may be of compelling influence in choosing projects for construction.

Such factors include the disruption of community and regional economies, scenic, historic or aesthetic considerations, the preservation of fish and wildlife, and similar considerations, which cannot be adequately evaluated in monetary terms. Other practical considerations that might preclude the theoretically desirable order of construction of projects would include the following:

(a) the availability of funds, whether from public or private sources, may be an important consideration in the scheduling of projects within each country in an extensive basin-wide plan. This factor alone may require selection of a small project providing urgently needed benefits even though the small project may have a lower benefit-cost ratio than a larger project requiring more funds than are available. On the other hand, it is important to recognize that a small project undertaken for such an immediate consideration might jeopardize an eventual development of far-reaching beneficial consequences.

(b) an urgent need to provide for such purposes as local or regional flood control, navigation, irrigation, or exceptional increases in power requirements may determine the order of project construction rather than the ratio of benefits to costs.

(c) the attitude of affected interests on the flooding of lands and improvements or to the effect of a project on other uses of the water resource may require postponement or abandonment of construction of projects that are the most attractive when viewed solely from the standpoint of their benefit-cost ratio.

GENERAL PRINCIPLE NO. 2

Cooperative development of the water resources of the Columbia River Basin should result in advantages in power supply, flood control, or other benefits, or savings in costs to each country as compared with alternatives available to that country.

DISCUSSION OF GENERAL PRINCIPLE NO. 2

This principle was used as a basic concept by the Commission in the preparation of the more specific principles recommended herein, and is recorded for future guidance in the application of those principles.

TRANS-BOUNDARY PROJECTS

Projects which could produce downstream benefits to be shared between the two countries may be located entirely in the upstream country, or may be trans-boundary projects in which the benefit-producing potentials of storage and head are partly in each country.

Such projects affect the level of water above the boundary and in consequence are subject to Article IV of the Boundary Waters Treaty of 1909. The principles presented elsewhere in this report are applicable directly to storage projects situated entirely in the upstream country and relate to the effects produced in the other.

To apply these principles to a trans-boundary project, it is first necessary to assign to each country an "entitlement" to the storage.

This entitlement or share of the benefit-producing potential of the storage would then form the basis for determination and apportionment of downstream benefits between the two countries in accordance with the principles recommended herein. In addition, an entitlement to at-site power generation should be determined based on the benefit-producing potential of the head and flow involved. Also, the respective entitlements to share in any other benefit-producing potentials should be determined if significant.

As a basis for determining the "entitlement" of each country to the benefit-producing potentials of storage and head at trans-boundary projects, the Commission recommends the following general principle:

GENERAL PRINCIPLE NO. 3

With respect to trans-boundary projects in the Columbia Basin, which are subject to the provisions of Article IV of the Boundary Waters Treaty of 1909, the entitlement of each country to participate in the development and to share in the downstream benefits resulting from storage, and in power generated at site, should be determined by crediting to each country such portion of the storage capacity and head potential of the project as may be mutually agreed.

DISCUSSION OF GENERAL PRINCIPLE NO. 3

The "entitlements" determined in accordance with this principle provide a basis for establishing benefit credits. The principle is designed to provide flexibility in the arrangements between the two countries for cooperation on trans-boundary projects. The entitlement of a country computed in accordance with this principle would be the basis for determining the share of downstream benefits due to that country in accordance with the other principles presented in this report for projects wholly in one country.

POWER PRINCIPLES

The setting in which principles for determining and sharing power benefits from the cooperative use of upstream storage in the Columbia River system would be applied is one in which significant changes are likely to occur within the life of projects that might be considered for development at this time.

At present the power loads in the United States portion of the Columbia Basin and adjacent areas of the Pacific Northwest are supplied almost entirely from hydro-electric plants. The downstream generating plants in the United States are now in a position to benefit materially from storage regulation upstream primarily through improvement of the dependable capacity and useable energy of the downstream plants. As the more economically attractive hydro plants are developed progressivly, it will become necessary and advantageous to add thermal plants to the system until ultimately the Pacific Northwest power system in the United States will become predominantly thermal.

In the course of this change, the character of the benefits to downstream hydro-electric plants in the United States from storage will change to benefits in the form of peaking capacity and thermal replacement energy and may change in value.

In Canada, the hydro-electric power potential has not yet been developed to a comparable extent. For this reason, the type of change envisioned in the United States is unlikely to occur in the Canadian portion of the Columbia River Basin and adjoining areas until a considerable period of time has elapsed.

In the light of the foregoing, the Commission has found it necessary in its formulation of principles for determination and sharing of power benefits to allow for changing conditions during the specified period that a cooperative development agreement or any extension thereof would be effective. The principles recommended below for the determination and apportionment of power benefits to be sufficiently flexible to provide for equitable arrangements to permit taking into due account the changing conditions expected.

Application of the power principles to conditions in the Columbia basin would require electrical interconnection between the power systems of the two countries to make possible delivery of the upstream country's share of the power produced in the downstream country from the use of stored waters.

Although such delivery could be accomplished initially with a somewhat limited degree of interconnection, the Commission is of the opinion that provision should be made for the eventual development of a broader, long-range plan for cooperative operation of the interconnected power systems of the two countries. Accordingly, the power principles include in addition to those governing cooperative use of stored waters, a principle providing for interconnection and coordination of the major power systems in the Columbia basin and adjoining areas in both countries so as to permit the power utilities of the two countries to gain the advantages of cooperative arrangements in power system operations.

POWER PRINCIPLE NO. 1

Downstream power benefits in one country should be determined on the basis of an assured plan of operation of the storage in the other country.

DISCUSSION OF POWER PRINCIPLE NO. 1

This principle is basic to a determination of the dependable capacity and usable energy that can properly be credited to operation of upstream storage for the benefit of hydro-electric power generation downstream. Emphasis is placed particularly on the concept of an assured plan of operation of the storage with the expectation that the downstream system will be developed and operated so as to make optimum use of the stream flow regulation provided.

It is a generally accepted engineering principle in the electric power field that any power supply which is classified as "firm" or "dependable" must be deliverable on such a schedule or plan as to assure availability of the power at the times when it is needed to serve the load, particularly during peak load periods.

It is, therefore, highly important that river-flow regulation be provided under an agreed operating plan or rule curve that will assure the dispatch of water by the owner of storage facilities to the owners of downstream hydro plants in such a manner as to meet the needs of the latter for delivery of firm power to their customers. Such a plan of operation will provide the maximum downstream power benefit consistent with the degree of coordination agreed upon.

It is expected that a general plan of operation of the upstream storage project will be estimated for the entire period of the agreement with the understanding that mutually satisfactory adjustments in the long-range plan of operaion can be made from time to time as necessary. This general provision for adjustment is additional to the flexibility for changes by either country which may be specifically provided for in the agreement. Factors that may bring about the need for adjustments in the operating plan are covered in the discussion of Power Principle No. 2.

POWER PRINCIPLE NO. 2

The power benefits attributable to an upstream storage project should be estimated in advance to the extent possible to the mutual satisfaction of the upstream and downstream countries. These estimates of power benefits should be subject to review in accordance with the agreed principles every five years, or more often as may be agreed, to take into account in subsequent estimates any change in previously assumed conditions and to insure optimum utilization of the storage and accurate determination of future benefits.

DISCUSSION OF POWER PRINCIPLE NO. 2

This principle is intended to provide in advance of construction of upstream storage reservoirs a long-range estimate of the expected benefits of the international cooperative undertaking. The estimate of benefits, expressed in power, or in monetary terms if necessary, would be determined on the basis of the current assured plan of operation as described under Power Principle No. 1 and in accordance with Power Principle No. 3.

It is contemplated that the appropriate agencies in each country will collaborate in the preparation of the estimate and that it will cover the entire period of the international agreement. Any extension of the agreement would also require similar estimates. It should be based on the relevant conditions of load and power supply expected to prevail during the period of the agreement. The assumed power supply should include the projects, both hydro-electric and steam-electric, considered most likely to be constructed to meet the long-range needs of the power systems concerned.

In estimating the long range power benefits attributable to upstream storage and in the periodic reviews provided for in this principle, due recognition should be given to the adjustments in storage operation that are likely to be required to meet power loads and other water use needs in either country.

Factors in either country which could change and thus alter the role of storage include: the magnitude and characteristics of the power loads to be served, installed generating capacity available in the hydro-electric plants on the affected systems, the amount of thermal generating capacity available and the requirements of other water uses. The time and effect of such changes should be anticipated by the appropriate Canadian and

United States agencies as far in advance as possible and taken into account either by provision in the assured plan of operation or by agreement on mutually satisfactory adjustment as a result of the periodic review of the plan of operation and long-range estimate as provided for in this principle.

In addition to the primary purpose of furnishing a long-range estimate of the benefits of the international cooperative undertaking the advance estimate and periodic reviews are expected to serve several other purposes. The agencies affected will be afforded a basis for anticipating the probable long-range use or role of the storage in the respective countries so that other developments on the affected power systems can be planned well in advance and timely provision made for their construction as required by each country. Assurance as to use of the storage would facilitiate advance planning of the transmission systems required to coordinate the storage operation with generating plants on the interconnected power systems. Information provided from the estimates would also aid the two countries in determining the timing and value of other projects of international scope in which they may be jointly interested.

POWER PRINCIPLE NO. 3

The amount of power benefits considered to result in the downstream country from regulation of flow by storage in the upstream country should be determined in advance by computing the difference between the amount of power that would be produced at the downstream plants with the storage regulation and the amount that would be produced without such regulation. This determination would be made on the assumption that upstream storage is added at an agreed-upon level or condition of storage and power supply. The storage credit position of the upstream storage thus established should be preserved throughout the period of the agreement.

DISCUSSION OF POWER PRINCIPLE NO. 3

Application of the with and without principle involves several significant determinations and procedures to insure that the upstream storage receives proper credit for its contribution toward meeting the load. Because of the fact that successive units of storage capacity added to a system of projects result in decreasing amounts of regulatory effect per unit, the time at which a project is considered as added to the system in relation to the time at which other storages are added affects the amount of regulatory effect and accompanying firm power benefit with which a particular storage project may be credited. Thus the conditions under which a project is considered as added determines its "credit position".

Under this principle, it is intended that the storage credit position of an upstream storage reservoir be determined on the assumption that it is added at an agreed-upon level of condition of storage and power supply. This "level" or "condition" might be defined by relating it to a "base system". The "base system" would be comprised of all developments existing at the time of negotiation of an agreement together with developments actually under construction at that time.

Since many estimates and computations have already been made on the basis of data available during the Commission's consideration of these principles, it is suggested that negotiations undertaken in the near future utilize as a base system the developments existing and under construction on January 29, 1959, the date of the two Governments' request for this report. The pertinent storage developments in the current base system are:

Project	Useable storage
Kootenay Lake	673,000 acre-feet
Hungry Horse	2,982,000
Flathead Lake	1,217,000
Albeni Falls	1,153,000
Coeur d'Alene Lake	225,000
Grand Coulee	5,072,000
Chelan	676,000
Brownlee	1,034,000
	13,032,000 acre-feet

If negotiations are undertaken or continued at a time when major changes have occurred, a revised base system should be agreed upon. Conditions of International Joint Commission Orders of Approval affecting any of these developments would continue to be applicable.

It is contemplated that the representatives of the two governments who negotiate arrangements under these principles would agree on the order in which the storages they have under consideration would be considered as added to the base system so that a credit position for each such storage could be established. It is intended under this principle to provide that the credit positions of the storages thus established will not be adversely affected by the addition of subsequent storage and that the storage credit of such agreed upon storages may increase or decrease only as the role of storage generally in the system changes.

POWER PRINCIPLE NO. 4

The amount of power benefits determined to result in the downstream country from regulation of flow by storage in the upstream country would normally be expressed as the increase in dependable hydroelectric capacity in kilowatts under an agreed upon critical stream flow condition, and the increase in average annual useable hydroelectric energy output in kilowatt-hours on the basis of an agreed upon period of stream flow record. Since this procedure requires relating the increased power production to the loads to be met in the downstream country and adjustment of the upstream country's entitlement to conform more nearly to its load requirements, consideration might be given in the negotiations to the adoption of arrangements that would be less de-

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pendent upon consideration of the load patterns in each country.

DISCUSSION OF POWER PRINCIPLE NO. 4

In determining the increase in dependable hydro capacity and in useable energy output at downstream plants resulting from upstream regulation, the estimates should be based on the ability of those plants, enlarged as necessary, to serve the coordinated system loads in the downstream country expected to be realized during the periods under consideration.

The critical flow period used to determine hydro plant outputs available for supporting dependable capacity on the downstream load would be that corresponding with the agreed-upon level or condition of storage and power supply as contemplated in Power Principle No. 3.

Estimates of increase in average annual useable energy output at the affected downstream plants should be based on an agreed upon period of stream flow record which is expected to give results representative of long term condtions.

It is expected that both dependable capacity and energy benefits will result during the early and intermediate stages of the storage operation, but during the later stages the power benefit may consist only of increased useable energy.

Whether the objectives are to produce the maximum firm power, peaking capacity or thermal replacement energy, the power useable on the downstream load is the basis for determining the monetary value of the power resulting from the cooperative arrangements.

Such value as defined later in Power Principle No. 5 would serve as the basis for adjusting the upstream country's entitlement as between capacity and energy, to amounts of equivalent total value, which conform more nearly to the requirements of the upstream country's load.

POWER PRINCIPLE NO. 5

Whenever it is necessary to place a monetary value on downstream power benefits arising in one country from storage operation in the other country, the value should be the estimated cost to the downstream country of obtaining equivalent power from the most economical alternative source available except where the appropriate Canadian and United States agencies specifically agree on some other basis of evaluation.

DISCUSSION OF POWER PRINCIPLE NO. 5

This principle is intended to provide a basis for the evaluation, in monetary terms, of downstream capacity and energy benefits attributable to upstream storages for whatever purposes such monetary evaluation may be required; but is intended to have application only in those cases where appropriate monetary values for specific purposes are not otherwise agreed upon by the appropriate United States and Canadian agencies. It is further intended that where such monetary values are agreed upon by the agencies, for any period during the life of the covering agreement, the value so agreed upon shall over-ride the provisions of this principle.

The alternative source used as a basis for the evaluation should be the most likely source available to furnish an amount of power equivalent to the power being evaluated and might be hydro-electric, thermal or some combination thereof.

POWER PRINCIPLE NO. 6

The power benefits determined to result in the downstream country from regulation of flow by storage in the upstream country should be shared on a basis such that the benefit, in power, to each country will be substantially equal, provided that such sharing would result in an advantage to each country as compared with alternatives available to that country, as contemplated in General Principle No. 2. Each country should assume responsibility for providing that part of the facilities needed for the cooperative development that is located within its own territory. Where such sharing would not result in an advantage to each country as contemplated in General Principle No. 2, there should be negotiated and agreed upon such other division of benefits or other adjustments as would be equitable to both countries and would make the cooperative development feasible.

DISCUSSION OF POWER PRINCIPLE NO. 6

It is assumed that each country would bear all capital and operating costs for facilities it would provide in its own territory to carry out the cooperative development. The upstream country's share of the power would be transmitted to the boundary by the downstream country at such points as may be most economical to the downstream country. Other points could be selected upon request of the upstream country provided that any excess costs to the downstream country are paid by the upstream country. Losses in transmission of the power to the international boundary from the points of generation would be borne by the upstream country. The voltage at which power would be delivered to the upstream country would be mutually agreed upon but such voltage should be a level that is in common use on the downstream power system through which the transfers of power are to be made.

The load factor at which the upstream country's share of power is delivered should also be agreed upon in advance. Basically, the downstream country should not be required to provide more facili-

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ties for generation and transmission to furnish the upstream country its entitlement of power than would be required if the power were to be used in the downstream country at the load factor generally applicable to its affected hydro plants.

POWER PRINCIPLE NO. 7

In addition to benefits from cooperative use of stored water, interconnection and coordination of the electric power systems to the extent that they are practicable and desirable, would also provide many mutual benefits which should be shared. Coordination being a continuing function would require specific arrangements on the part of the operating agencies as the need arises.

DISCUSSION OF POWER PRINCIPLE NO. 7

The first six power principles recommended in this report are directed to determination and apportionment of benefits which would result from international cooperation in the use of stored waters. These are basically hydraulic benefits which can be realized by storing flood flows during the spring and summer months and releasing the stored waters during the fall and winter months when they can be put to use for the production of firm power at the storage site and downstream. Electrical interconnection between the power systems of the two countries would be required to make possible delivery of the upstream country's share of the power produced in the downstream country from the use of stored waters, but the interconnection capacity provided for this purpose would be only that needed to accomplish such delivery. This limited degree of interconnection would not, however, make possible the greater benefits that would accrue to the two countries from a comprehensive plan of interconnection and coordination.

Such coordination should be recognized in the development of the agreed upon plan of upstream storage operation and in the computation of system power benefits. Separate arrangements may be required for sharing coordination benefits because the electrical coordination envisaged could extend geographically beyond the service areas of the generating plants or power systems directly benefitted by the release of stored waters from storage projects constructed by the upstream country.

It is recognized that the power systems in British Columbia are not now developed to the same extent as in the United States portion of the Columbia River basin, but it is the intention of this principle to provide for long-range international cooperation between the systems of the two countries as they continue to develop in the future.

Under arrangements for coordination, it would be expected that all participating power systems would retain their local autonomy but would necessarily operate their generation and transmission facilities under the terms of appropriate agreements with a view to maximizing mutual benefits. The arrangements should set forth the broad operating principles to be observed and should be written in sufficient detail to describe the specific purposes and objectives.

FLOOD CONTROL PRINCIPLES

Among the sections in the United States to which principles for flood control benefit determination and sharing would be applicable are the Kootenai River downstream from Bonners Ferry, Idaho, and the lower main stem of the Columbia River. These areas now have partial protection against flooding and there are plans for utilization of storage in the United States to be developed primarily for power purposes in such a way that ultimately a high degree of protection against major floods would be obtained.

As successive blocks of storage for flood control purposes are added to the system, the amount of flood damage that can be prevented per unit of flood control storage decreases. Accordingly, the value that can be assigned to upstream storage for flood control purposes is greater for projects to be constructed in the near future than for those to be built later.

Also, in the Columbia Basin the hydrologic and hydraulic characteristics are such that storage can be operated in the interests of flood control to a considerable extent with little, if any, interference with the operation of the same storage project in the interests of power generation.

These factors, as well as other information available to the Commission, have been taken into account in formulating the following principles for determination and sharing of flood control benefits which may result from cooperative development of storage in the Columbia River Basin.

FLOOD CONTROL PRINCIPLE NO. 1

Flood control benefits should be determined on the basis of an assured plan of operation and flood control regulations agreed to in advance.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 1

The assured plan of operation for flood control would not be a separate plan of operation but rather a joint or composite plan of operation of a given storage project in the interests of flood control as well as for other purposes, principally power. The plan of operation for any reservoir included in the flood control plan, therefore, should be worked out initially so as to obtain the best combination of benefits for all purposes. In the Pacific Northwest meteorological and hydrological conditions and the requirements for storage operations in the interest of power and flood control are such that little, if any, loss of ability to maximize power benefits is required to accommodate flood control. In any event, the plan of operation worked out in accordance with these principles would be the basis for determination of the flood control and power benefits to be shared.

Once the plan of operation is agreed to, normal operations for both power and flood control would be in accordance with the plan.

It is to be expected that both the upstream storage interests and the downstream power and flood control interests may wish from time to time to request or suggest deviations from the plan.

If such deviations would involve an adverse effect on the other party at interest it would be expected that a basis for compensating for the adverse effect would also be proposed. Such deviations would then be made possible if the deviations and any required compensation were mutually acceptable to both parties. If the upstream country wished to have the option of using alternative storage to provide equivalent downstream flood control effects as contemplated in the plan of operation, such option should be provided for in the agreement.

It is assumed that acts of God, emergencies, and other events over which neither party has control, would be interpreted and handled in the manner usually contemplated in a "force majeure" clause in an agreement.

FLOOD CONTROL PRINCIPLE NO. 2

The downstream flood control benefit of the upstream storage to be operated in accordance with an agreed-upon flood control plan should be estimated in advance on the basis of the effectiveness of such storage in meeting the flood control objectives applicable in the downstream country at the time the upstream storage is provided.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 2

This principle places prospective Canadian storage to be operated in accordance with an agreed-upon flood control plan in exactly the same position that any concurrently prospective United States storage for flood control purposes would have. The effectiveness of all flood control storage is measured in terms of the flood control objectives applicable at the time the storage is to be provided and the effectiveness determined at that time is applicable for the entire life of the project in question or for the period of agreement in the case of Canadian storage.

In the United States the current primary flood control objective is to obtain storage sufficient to control a flood of the magnitude of that of 1894 at The Dalles to 800,000 cfs.

All additional storage in the United States or Canada necessary to achieve this objective (approximately 7½ million acre feet of storage usable for flood control) would, if included in the flood control plan, be given equal credit on the basis of the effectiveness of each acre foot of such storage in controlling floods at The Dalles. Storage either in the United States or Canada added after the necessary amount has been reached to control the 1894 flood to 800,000 cfs would, if included in the flood control plan, be evaluated at a lesser rate based on the average value of all additional storage needed to control the 1894 flood at The Dalles to 600,000 cfs.

Local flood control objectives have also been identified in other parts of the basin especially on the Kootenai River downstream from Bonners Ferry where control of the 1894 flood to a maximum of 600,000 cfs is desirable. Storage either in the United States or Canada should be entitled to credit on the basis of satisfying such local objectives.

FLOOD CONTROL PRINCIPLE NO. 3

The monetary value of the flood control benefit to be assigned to the upstream storage should be the estimated average annual value of the flood damage prevented by such storage.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 3

The average annual value of flood damage prevented by upstream storage can be computed by conventional methods using stage-frequency and damage-frequency relationships. The methods are described and their application illustrated in the most recent report of the Corps of Engineers on the Columbia River Basin recently submitted by the Division Engineer, US Army Engineer Division, North Pacific, to the Chief of Engineers under the title "Water Resources Development, Columbia River Basin" dated June 1958.

FLOOD CONTROL PRINCIPLE NO. 4

The upstream country should be paid one-half of the benefits as measured in Flood Control Principle No. 3, i..e, one-half of the value of the damages prevented.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 4

In the event that application of this principle should indicate a payment to the upstream country greater than the estimated cost of alternative means of obtaining equivalent flood control in the United States the requirement of General Principle No. 2 that there should be an advantage as compared with available alternatives would not be satisfied and consideration should be given to this circumstance in the negotiations.

FLOOD CONTROL PRINCIPLE NO. 5

The amount due to the upstream country under the foregoing principles should be determined in advance of construction of each storage project. Payments to cover the entire period that the arrangements are to be effective should be made in cash as a lump sum or as periodic amounts as may be agreed upon

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INTERNATIONAL NEWS

The Colombo Plan is not a partnership of ideologies or doctrines, "but it is a partnership which has as its sole objective the welfare and prosperity of the member countries of the organization," stated Dr. R. Subandrio, Minister of Foreign Affairs, Republic of Indonesia, at the eleventh meeting of the Consultative Committee of the Colombo Plan, held in Jogjakarta, in November. Similarly, both Prime Minister Diefenbaker and the late Dr. Sidney Smith, Minister of External Affairs, have expressed the view that, participating in The Colombo Plan, countries recognize the importance to the world at large of careful development of both natural and human resources in the countries of South and Southeast Asia.

Canada has played a significant part in the Colombo Plan since its inception in 1950. At that time the Commonwealth foreign ministers, meeting in Colombo, set up a plan for cooperative economic development of South and South-East Asia for six years ending June, 1957. In 1955, the Plan was extended till June 1961 and at the November 1959 meeting it was extended another five years from 1961. Whereas the membership in 1950 included only Commonwealth countries—Australia, Canada, Ceylon, India, New Zealand, Pakistan, and the U.K.—it has been extended to all countries of South and South-East Asia, Japan and the U.S.

During the year 1958-59 Canada contributed $35 million to Colombo Plan projects, bringing her total as of March 31, 1959, to more than $231 million. Beyond this, Canada has made special grants of wheat and flour to India, Pakistan and Ceylon with a total value of $70 million. She has sent 134 experts in public health, agriculture, fisheries, mining, engineering and aerial survey to South and South-East Asian countries and has received 1035 trainees in Canada from Colombo Plan countries.

Hydro-electricity and Irrigation

The Warsak Project on the Kabul River about 19 miles northwest of the city of Peshawar, Pakistan, is one of five irrigation and power development projects which Canada has contributed to in Pakistan. Into the Warsak Project alone she has put $33.5 million.

The total drainage area to the project site is approximately 26,000 square miles, for the river rises in Afghanistan about 60 miles north of the capital city, Kabul. When the Warsak Dam is completed it will supply 160,000 kw. of electric power to northwest Pakistan and the surrounding districts. Power will be able to be transmitted to the growing industrial areas to the south where there is a shortage of power as the output of the Warsak Project is increased.

The main dam is a concrete gravity overflow structure approximately 700 ft. long, rising 220 ft. above the lowest level of the river bed. Downstream of the dam is a power house which at present houses four units but has space for an additional two. Both the Warsak Dam and the power house have been designed by Canadian firms and the generators and electrical equipment, manufactured in Canada. In January 1959, 157 Canadians and 10,673 Pakistanis were employed in various phases of the project. While the project manager is a Canadian, both Pakistani and Canadian engineers are at work there.

The Thal Irrigation and Colonization Project on the River Indus in Pakistan has been carried out with capital and technical aid from Canada, the U.K., Australia and New Zealand. The project

Canadian Assistance Under The Colombo Plan
To March 31, 1959

Country	*No. of Experts Sent*	*No. of Students Trained*	*Expenditures on Technical Assistance*	*Allocations of Capital Assistance*	*Total of Expenditures on Technical Assistance and Allocation of Capital Assistance*
Burma	10	77	494,931	399,563	894,494
Cambodia	4	16	113,192	64,634	177,826
Ceylon	42	77	1,321,075	13,309,917	14,630,992
India	20	295	1,510,583	122,241,019	123,751,600
Indonesia	8	163	832,494	2,435	834,928
Laos	1	17	96,143	—	96,143
Malaya	16	17	347,131	209,006	556,731
Nepal	—	—	—	60,000	60,000
North Borneo	1	6	37,267	3,000	40,267
Pakistan	18	263	1,324,724	75,293,222	76,617,946
Philippines	—	2	5,100	—	5,100
Sarawak	4	6	78,617	—	78,617
Singapore	3	6	71,968	55,000	126,968
Thailand	1	5	52,431	—	52,431
Vietnam	—	85	289,494	5,700	295,194
	6 (1)	—	42,507 (2)	—	42,507 (2)
	134	1,035	6,617,657	211,644,090	218,261,747

(1) Two or more countries. (2) Contributions to Technical Co-operation Bureau.

includes the settling of over 50,000 family units in 700 new villages with modern sanitation, markets and electricity. The area, which less than a decade ago was shifting sands, is now a fertile belt of more than 500,000 acres of cotton, sugar cane, maize, fodders and wheat.

The Shadiwal Hydel Scheme, a major irrigation project for East Pakistan, will produce 12,000 kw. of firm power from a fall on the Upper Jhelum Canal. The generating sets and some of the construction machinery are being given by Canada.

The Karnaphuli Hydro-Electric Station is in process of being connected with the **Steam Station At Siddhirganj** (Dacca) by means of a 132 kv. transmission line for which Canada is in large part responsible. State ipment for a steam station at Khulná and much of the plant and equipment at Goalpara have been made possible by Canadian contributions through the Colombo Plan.

The Gal Oya Valley Development in Ceylon, based upon the impounding of the waters of the 62-mile long Gal Oya River in a giant reservoir, is a multipurpose project for flood prevention, irrigation and hydro-electric power. Though the project has been financed principally by national funds, Canada has helped by providing the power transmission extension system and power-driven lift irrigation equipment for experimental purposes.

Other Projects

"Canada Dam" on the Mayurakshi River in West Bengal is but one of the hydro-electric power and irrigation projects in India contributed to by Canada. **The Kundah Project**, one of the largest power installations in Madras, and **The Shadiwal Project** in West Pakistan have also been the concern of Canadian engineers under the Colombo Plan. **The Mekong River Scheme**, which is an international project to benefit four Colombo Plan countries, Laos, Thailand, Cambodia and Viet-Nam, is to be studied by a Canadian expert to determine feasibility, costs, and problems involved in making an aerial survey along the Mekong.

Although 40% of all Canada's financial and technical aid through the Colombo Plan has been devoted to water power and irrigation projects, Canada has also contributed to the development of fisheries in Ceylon; the first atomic reactor in India; transportation and communications facilities in India, Ceylon and Indonesia; and the equipping of a Technical school in Singapore. Canada ranks third of the Colombo Plan countries in number of training places provided for Colombo Plan students from South and South-East Asia.

Month to Month

Commonwealth Scholarship and Fellowship Plan

The first Commonwealth Education Conference held in Oxford, England, July 15-28, 1959, laid the foundations for a Commonwealth Scholarship and Fellowship Plan for interchange of students within the Commonwealth countries. The plan includes all phases of high education — humanities, sciences, and vocational courses. The first awards—will be made to students who already hold a first degree and wish to do advanced work. A limited number of Commonwealth Visiting Fellowships will also be available for senior scholars of established reputation. Most scholarships will be offered by the country receiving the scholar, after having made its own selection of Scholars and Visiting Fellows. Candidates will apply on their own initiative.

Dean Gaudrefroy, of Ecole Polytechnique, Montreal. was a member of the Canadian delegation to the planning conference.

French Government Scholarships for Canadian Engineers and Technicians

The French Government has established a *Service de Cooperation Technique* to organize and coordinate foreign students' work in France, both in formal courses and in training positions in industry. They offer a grant of 75,000 francs a month (considerably more in purchasing value than $200 a month in Canada), free return trip from France to Canada, free travel relating to work while in France, and comprehensive medical coverage.

Candidates must hold an engineering degree from a university of high standing; must have had some field experience for at least one year; must have a sufficient knowledge of French; and must present good references and a proposed plan of study. Letters of application, listing date and place of birth, academic training, practical experience, references, knowledge of French, and proposed duration of stay and plan of study should be sent *immediately* to: Mr. Raymond Treuil, Chairman of the Comité France-Technique, c/o French Embassy, 464 Wilbrod Street, Ottawa, Ont. Professional engineers and university professors who wish to supplement their knowledge in their particular field are particularly eligible for such scholarships.

Education Conference in Toronto, 1962

The Second Canadian Conference on Education will take place in the Royal York Hotel, Toronto, during the week of February 19, 1962. A group of Canada's outstanding educators and lay thinkers is in process of determining the program for this convention. The National Committee met in Montreal recently, with Kurt Swinton and Dr. Robert Gauthier as co-chairmen, and drew a record attendance.

University Appointments

Dr. Claude Bissell, president of the University of Toronto, has announced the appointment of two new department heads. Prof. J. G. LeRoy will take over the department of chemistry, and Prof. J. B. Breckenridge, the department of chemical engineering and applied chemistry. Both appointments take effect July 1.

The appointment of new faculty members in electrical engineering at McMaster University is announced by Dr. J. W. Hodgins, dean of engineering. Dr. C. A. Edward Uhlig is appointed associate professor of electrical engineering and G. J. Hoolboom, assistant professor in the department.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on October 17, 1959.

Member: J. L. Baardman, Montreal; J. Beattie, Ottawa; S. M. Blair, Toronto; J. N. Clinton, Toronto; P. H. Davies, Fort William; S. B. Ford, Montreal; N. S. Hammond, Kitimat; S. F. Hunt, Winnipeg; W. J. Lenson, London; A. P. MacGrath, Ottawa; I. C. MacLean, Toronto; M. J. Palmer, Hamilton; J. M. Philip, Montreal; A. Rutka, Toronto; J. J. Schoustra, Toronto; H. Stephens, Kitchener; C. Szollosy, Schefferville; B. L. Vass, Montreal; C. G. Woof, Toronto.

Junior: R. Collins, Toronto; Y. I. Fellman, St. John's, Nfld; J. J. Grieco, Shawinigan Falls; T. T. Morrison, Montreal; I. Nabi, South Bend, Ind; A. R. Rowcroft, Montreal; M. T. Vickers, Montreal.

Junior to Member: C. L. Bessette, Iberville; L. J. Bandiera, Kitimat; M. J. Kitchen, North Bay; J. K. Park, Toronto; H. A. C. Stokes, New Westminster; W. J. N. Throop, Belleville.

STUDENTS ADMITTED

University of Toronto: G. R. Biggs; Yiu-Cho Li, Yiu-Chung Li, D. L. Meyers, L. G. Richings, H. Shifman, Cho-Yuk Sin, J. Timusk, A. Tunner, C. Warchol.

Sir George Williams College: B. Christiansen, R. E. Doyle, B. D. Emery, P. P. Jurgutis, J. Labreche, C. Maletskas, M. Rosenbloom, D. K. Schroder.

McGill University: S. R. Allen, A. S. Hill, R. G. Knystautas.

University of Manitoba: B. M. M. Long.

Dalhousie University: P. W. H. Willcock.

St. Joseph University: C. Losier.

Northwestern University: G. T. Jorgenson.

University of Toronto: R. E. Anderson, B.A.Sc., (Mech.) 1959; C. T. David, B.A.Sc., (Engrg. Physics) 1959.

Imperial College (University of London): G. F. Dorling, B.Sc. (Chem.) 1959.

University of British Columbia: D. C. Baynes, B.A.Sc., (Civ.) 1959.

Application through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective:

ALBERTA

Members: R. A. Cimolino, G. A. McCreary; **Junior:** M. J. Burgess, G. H. Palmer; **Junior to Member:** N. G. Brown.

SASKATCHEWAN

Members: I. Brand, R. L. Cheesman, D. D. Davison, N. F. Gordon, D. M. Kilgour, J. J. Kovach, B. H. Lacey, M. L. Olynyk, F. D. Patton; **Juniors:** D. Hortensius, D. D. McLean, J. S. Tulooch; **Junior to Member:** D. L. Fuller, H. G. Wiber.

NOVA SCOTIA

Members: G. W. Baker, F. R. Fraser.

PRINCE EDWARD ISLAND

Junior to Member: L. A. Coles.

KINGSTON REGIONAL TECHNICAL CONFERENCE

Automation and Control

Saturday May 7, 1960

10 a.m. **REGISTRATION:** By special form as mailed to each member or with L. C. Miller, 277 Mack St., Kingston, or at the conference.

11 a.m. **OPENING ADDRESS AND TECHNICAL PAPERS:** Ellis Hall, Queen's University.

12.30 p.m. **LUNCHEON:** In the Students' Union, Queen's University. Ladies are welcome.

PROGRAM OF TECHNICAL PAPERS

11 a.m. DR. ARTHUR PORTER, *Dean of Engineering—University of Saskatchewan.*
Growth of Automata

2 p.m. MR. P. HERTZL, *Sperry Gyroscope*
A Numerically Controlled Positioning System

MR. J. D. LEE, *J. D. Lee & Co. Ltd.*
The Application of a Small Digital Computer to Some Civil Engineering Problems

3 p.m. MR. A. DUGUID, *Computing Devices of Canada*
Dead Reckoning Airborne Navigation Systems

MR. G. A. LOCKE AND MR. R. H. ANDRES, *Canadian Industries Ltd.*
Instrumentation Problems in Hydrogen Gas Generation

4 p.m. A paper delivered by a Service Officer on a Military Application of Automation.

A paper delivered by a Student Member on a subject associated with Automation and Control. This paper is being selected on a competitive basis from those submitted by a number of educational institutions.

LADIES' PROGRAM: Ladies are welcome to attend any of the technical papers. A tour of Fort Henry and tea have been arranged.

6.30 p.m. **RECEPTION:** Burgundy Room, La Salle Hotel.

7.30 p.m. **DINNER-DANCE:** In the La Salle Hotel, dress informal.

Accommodation will be arranged as requested on the registration forms.

Plan Now to Attend

THE KINGSTON REGIONAL TECHNICAL CONFERENCE

George McKinstry Dick

PRESIDENT

THE ENGINEERING INSTITUTE OF CANADA

1960 — 1961

GEORGE McKINSTRY DICK, M.E.I.C., was born in Scotland and attended public schools over there, prior to coming to Canada. After a short sojourn in the Canadian West, he took up residence in Sherbrooke, Quebec, and entered the employment of Canadian Ingersoll-Rand Company as an apprentice. During World War I, he was employed in the design of machinery for the manufacture of munitions. He was a student at Bishops University in Lennoxville in 1920 and later attended McGill University, Montreal, where he graduated with the degree of Bachelor of Science, Honours in Mechanical Engineering, in 1924. He was British Association Medallist at graduation and was holder of the Babcock & Wilcox Scholarship. His summer essay took prizes in The Canadian Pulp & Paper Association and also The Engineering Institute of Canada.

Eager for a diversified career, Mr. Dick gained extensive knowledge in the pulp and paper field by being associated with The Brompton Pulp & Paper Company at East Angus, Quebec, as well as experience in the design of boilers and stockers by working for Babcock-Wilcox & Goldie-McCullough Limited at Galt, Ontario. He eventually re-entered the employment of Canadian Ingersoll-Rand Company where his activities have brought him in contact with a wide range of engineering interests. For many years he was Chief Hoist Engineer, and, as such, pioneered the design of a considerable volume of the mine hoists used in Canada today.

During World War II, Mr. Dick was Chief Engineer of The Sherbrooke Pneumatic Tool Company, a subsidiary of Canadian Ingersoll-Rand, and was responsible for the design of much of the shell manufacturing equipment used by this company.

His interests, however, were not confined to engineering, and he later became Technical Assistant to the Works Manager of Canadian Ingersoll-Rand Company Limited, a position he held until 1945 when he was appointed Manager of Engineering with dutics which embraced management of all phases of his company's engineering and technical activities. These duties were later broadened to include complete control of the company's purchasing program, and he became Manager of Engineering and Purchasing. Since 1952, Mr. Dick has been Chief Engineer and has since then devoted his time principally to the development of new products, materials and processes.

Mr. Dick is a Past Vice-President of The Engineering Institute of Canada, a member of the American Society of Mechanical Engineers, The Technical Association of Pulp & Paper Industry of the U.S.A., The Corporation of Professional Engineers of Quebec, The Canadian Institute of Mining and Metallurgy, The Canadian Pulp & Paper Association, and The British Association for the Advancement of Science.

With the late Dr. Armand Crepeau, he founded the Eastern Townships Branch of The Engineering Institute of Canada. He was a charter member and the Branch's first chairman. Mr. Dick was for several years Regional Representative for the Eastern Townships on the Council of the Corporation of Professional Engineers of Quebec. He was a member of The Engineering Institute of Canada's Committee on Confederation, and is now a member of the Corporation of Professional Engineers of Quebec's Committee on Confederation.

When the Engineers Confederation Commission was set up jointly by The Engineering Institute of Canada and The Canadian Council of Professional Engineers, Mr. Dick was appointed its Vice-Chairman.

Mr. Dick is a member of the St. George's Club, Sherbrooke, and a Past-President and member of Sherbrooke Y.M.C.A. He is a Past-President, Past Honorary President, and member of the Sherbrooke Snow Shoe Club, and a member of Sherbrooke Curling Club. He is a member of the Session of St. Andrews Presbyterian Church, Sherbrooke, and a Governor of the Sherbrooke Hospital.

Keenly interested in Education, Mr. Dick is a member of the Advisory Committee of the Faculty of Science of the University of Sherbrooke and has also assisted in giving lecture courses.

Mr. Dick is married and has one son, James, who is a graduate in science of Bishops University, Lennoxville, and a graduate in engineering of McGill University.

During almost half a century, Mr. Dick has taken a leading part in the engineering development of this country. He has travelled extensively both on this continent and in Europe and in this way has kept himself well abreast of important engineering trends.

Personals

D. A. Barnum, M.E.I.C. (Michigan '29) has been appointed vice-president and general manager, Transmission Tower Division of Beamer & Lathrop Limited, Welland, Ont. Mr. Barnum resigned in November from Provincial Engineering, Ltd., Niagara Falls, Ont., where he was manager of the tower division.

D. A. Barnum, M.E.I.C.

J. T. Dyment, M.E.I.C.

J. T. Dyment, M.E.I.C. (Toronto '29), chief engineer of Trans-Canada Air Lines, has been appointed to represent air transportation on the Engineering Activity Board of the Society of Automotive Engineers.

E. A. Allcut, M.E.I.C. (Birmingham '09), Professor Emeritus of Mechanical Engineering at the University of Toronto, has been appointed commissioner of the Ontario Fuel Board by the Ontario Government.

S. Bonser, M.E.I.C. has been named works manager of Anthes Steel Products, Toronto. This company was formerly Standard Iron and Steel Works Ltd.

Clarence MacLeod Pitts, M.E.I.C. (McGill '14) has been appointed a director of British Oxygen Canada Limited, Toronto. Mr. Pitts is president of the People's Gas Supply Company, Ottawa.

Casimir C. Flis, S.E.I.C. (McGill) has been made town engineer of Newmarket, Ont.

H. W. Short, M.E.I.C., recently retired sales manager of Dominion Bridge, Toronto, has been appointed director of public relations and sales representative of the Sault Ste. Marie Branch of Dominion Bridge.

Robert Ford, M.E.I.C. (McGill '22) has retired as director of engineering at the Dominion Rubber Company, Montreal, and is residing in Ottawa.

H. G. Welsford, M.E.I.C., president and a director of the Dominion Bridge Company, and president and managing director of the Dominion Engineering Works, has been elected to the board of directors of The Royal Bank of Canada.

J. B. Mawdsley, M.E.I.C. (Princeton '24) has been appointed director of the new Institute for Northern Studies established by the University of Saskatchewan on its campus. Dr. Mawdsley will retain his present position as professor and head of the department of Geology at the university.

C. Ritchie Timm, M.E.I.C. (McGill '30) is the new director of engineering for the Dominion Rubber Company, Montreal.

C. R. Timm, M.E.I.C.

P. W. Barchard, M.E.I.C.

Philip W. Barchard, M.E.I.C. (British Columbia '40) has been named general manager of B.C. Electric's gas division.

Ralph R. Willis, M.E.I.C. (New Brunswick '31) is the new vice president and general manager of Ross Engineering of Canada.

James E. Neilson, M.E.I.C. (Queen's '28) is the new president and chief executive officer of Foster Wheeler, St. Catharines, Ont.

W. A. Cairns, M.E.I.C. (Alberta '36) has been appointed superintendent of Cominco's new Caustic Chlorine Department in Trail, B.C.

Patrick J. Kelly, M.E.I.C. (Manitoba '38), president of A. M. Kelly & Sons, Winnipeg, has been elected president of the Prairie Road Builders' Association.

T. G. Quance, M.E.I.C. (Toronto '38) has been made president of CLM Industries (formerly Canadian Line Materials Limited).

W. H. Powell, M.E.I.C. (Toronto '39), general manager of the Peterborough Utilities Commission, has been elected president of the Peterborough Chamber of Commerce.

A. F. Mosher, M.E.I.C. (University of B.C. '44), formerly vice-president, sales, with Croname (Canada), has been appointed to establish the Ontario Branch of Philip French Sales, Montreal. Headquarters will be in Toronto.

W. W. Robertson, M.E.I.C. (Saskatchewan '45) has been transferred by his firm, the Aluminum Company of Canada, to Switzerland where he will attend the Centre d'Etudes Industrielles.

J. W. Brison, M.E.I.C. (Queen's '48) has been appointed vice-president and manager of Windsor operations of Giffels & Vallet of Canada, Ltd., consulting engineers, Windsor, Ont.

Gregory R. Williams, M.E.I.C. (Toronto '48) has left C. D. Carruthers & Wallace Consultants Ltd. to establish his own practice of structural consulting engineering.

L. A. Parker, M.E.I.C. (McGill '51) has left John B. Parkin Associates and Giffels and Vallet of Canada with whom he was an electrical project engineer to form his own electrical consulting firm in Port Hope, Ont. under the name of L. A. Parker and Associates Limited.

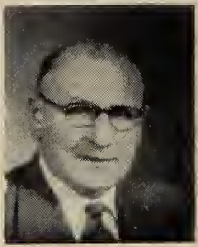
L. A. Parker, M.E.I.C.

Capt. D. H. Curling, JR.E.I.C.

Capt. David H. Curling, JR.E.I.C. (McGill '52), who has been attending the Royal Military College of Science, Shrivenham, England, has taken up the position of test officer, experimental and test wing, Army Development Establishment, Ottawa.

(More Personals on page 155)

OBITUARIES



J. Reed,
M.E.I.C.

J. E. Wainwright,
M.E.I.C.

Word has been received by the Institute of the passing of **Arthur Healy Dargie**, M.E.I.C., on September 8, 1958, at the age of 42. Mr. Dargie was for seventeen years connected with the Department of Highways & Public Works, Halifax, N.S.

Roland Kenneth Kilborn, M.E.I.C. died December 22, 1959, in Atlanta, Georgia. He was 56.

Mr. Kilborn was born in China under British registry. He was educated at North Toronto Collegiate Institute and at Queen's University. In 1947 Mr. Kilborn formed a consulting company specializing in the design of mining and milling plants, water supply and sewage treatment plants.

Mr. Kilborn was president of Kilborn Engineering Limited, Toronto. A Member of the Institute since 1945, he also belonged to the Canadian Institute of Mining and Metallurgy; the Ontario and Quebec Professional Engineers Associations, and the Canadian Institute on Sewage and Sanitation.

Harold Victor Serson, M.E.I.C., died suddenly in Orlando, Florida, on January 8, 1960. He was 77.

After graduation from the University of Toronto in 1905, Mr. Serson's first professional experience was on the construction of the Hudson River Tunnels in New York City. He continued in construction work in the United States until 1914, when he began a private practice in Arnprior, Ontario. During World War I, he served for three years in France with the Canadian Engineers.

For the next 32 years, Mr. Serson worked on construction projects across Canada, including hydro-electric developments at Island Falls, Ont.; Ottawa; Calgary; Dalhousie, N.B.; Masson, Shipshaw and Valleyfield, Que.; and Campbell River, B.C. He was connected with the Foundation Company for 16 years, and at the time of his retirement in 1951 was with the General Construction Company of Vancouver.

Mr. Serson joined the Institute as Associate in 1909, became a Member in 1940, and was made Life Member in 1947.

John Reed, M.E.I.C., a former councillor of the Institute representing the Saint John Branch, died suddenly in hospital at East Riverside, N.B., December 22, 1959. He was 63.

Mr. Reed was born at Trinity Bay, Nfld. and educated in Montreal. Graduating from McGill, he went to work as a draughtsman for the Phoenix Bridge Company, Montreal, until 1923 when he joined Canadian Vickers Limited as chief draughtsman. During World War I he served with the Ambulance Corps and with the Engineers of the Royal Canadian Army.

In 1928 Mr. Reed left his position as assistant chief engineer of Canadian Vickers' structural steel department to become chief engineer with the Saint John Dry Dock Company, Saint John. He retired from the post in 1958 and since that time had been doing consulting work for the company.

A former vice-president for New Brunswick and Prince Edward Island of the Canadian Institute of Steel Construction, Mr. Reed had also been a chairman of the Saint John Branch of the Institute and a member of the Association of Professional Engineers in New Brunswick.

Kenneth K. Pearce, M.E.I.C., died at Dewittville, Que., on August 8, 1959. For many years a resident of Montreal, Mr. Pearce retained his membership in the Montreal Branch of the Institute though he moved to Dewittville in July, 1959.

A graduate of the University of Toronto, Mr. Pearce started work in Montreal at the Dominion Bridge Company and was with that company for many years. Subsequently he was with Monsarret & Pratley, Consulting Engineers, and during depression years he was in the office of Noranda Gold Mines. Mr. Pearce was also employed at Canadian Vickers for a number of years.

Since 1950 Mr. Pearce had been with Brian Perry, Consulting Engineers, Montreal. He was granted a Life Membership in the Institute in January, 1957.

James George Radenhurst Wainwright, M.E.I.C. chief engineer of the Toronto Harbour Commission from 1929 to 1936, died December 10, 1959 at the age of 89.

A graduate of McGill, Mr. Wainwright began his work with the Commission in 1911 and had a major part in developing the present port facilities.

Mr. Wainwright's affiliation with the Institute began in 1890 when he applied for Student Membership. He was granted Life Membership in 1941.

Until his retirement in 1941, Mr. Wainwright acted as a consultant to the Toronto Harbour Commission.

Harold William B. Swabey, M.E.I.C., chief inspector of steel for the Department of Militia and Defence during World War I, died on January 30, 1960, at the age of 80.

Mr. Swabey was born in Bedfordshire, England and educated at the Crystal Palace School of Practical Engineering in London. He came to Canada in 1907. Prior to World War I, he was engaged in railroad construction. Mr. Swabey was supervising engineer on the construction of the Quebec and Saguenay Railway and he served the Canadian Pacific Railway Company as resident engineer on construction of the Campbellford-Lake Ontario and Western Railway.

For several years Mr. Swabey worked as construction engineer with Lockwood Greene and Company of Canada and in 1922 established the Service Engineering Company in Montreal. In 1926 he joined J. T. Donald & Company, Montreal and Toronto, general consulting engineers, and later became managing-director of that company.

During World War II Mr. Swabey worked with the Defence Purchasing Board and in 1946 he was named Assistant Steel Controller of the Department of Reconstruction and Supply. Retiring from active government service in 1950, he took up the position of town engineer in Pointe Claire.

A Life Membership in The Institute was bestowed upon him in 1947, after 37 years of membership.

News of Other Societies

IAEA Conferences on Isotopes and Reactors

Two major scientific conferences and eleven symposia are included in the provisional schedule of meetings to be organized by the International Atomic Energy Agency in 1960. One large conference will deal with radioisotopes in the physical sciences and industry; the other will concern itself with problems of medium and small-size reactors. The tentative list of symposia, for which invitations will be extended to all Agency member states, includes:

Fuel element fabrication
Vienna, May 3-6.
Radiation dosimetry
Vienna, June 7-13.
Inelastic scattering of neutrons in solids and liquids
Vienna, October 11-14.
Neutron pile (reactor) research
Vienna, October 17-21.
Nuclear ship propulsion
mid-November.
Experimental and test reactors
Vienna, November 28-December 2.
Education and nuclear energy
Argentina, end of year.

Electrical Engineers' Exhibition (London)

The Ninth Electrical Engineers' Exhibition, a display by the leading manufacturers of Britain's Electrical Industry, will be held at Earls Court, London, April 5 to 9. Nearly 450 manufacturers will show their products, covering every aspect of the generation, distribution and utilization of electricity.

Society for Experimental Stress Analysis

"Stress Analysis of Propulsion Systems" is the theme chosen for the 1960 Spring Meeting of the Society for Experimental Stress Analysis to be held in Indianapolis, Indiana, May 18-20. Further information about the meeting can be obtained from: Society for Experimental Analysis, Post Office Box 168, Cambridge 39, Mass.

World Power Conference

The Madrid Sectional Meeting of the World Power Conference will be held in Madrid, Spain, June 5-9, 1960. The five technical sessions will cover the following subjects: methods of investigation of energy sources and requirements; efficiency of production and utilization of energy; technical developments in transportation; establishment of nuclear reactors on an industrial scale; and functional interrelation between conventional and nuclear production of energy.

Machine Tool Exhibition

Sponsored by The Machine Tool Trades Association of Great Britain, the International Machine Tool Exhibition will be held in London June 25 to July 8, 1960.

Conference on Medical Electronics

The Third International Conference on Medical Electronics will take place in London, July 21-27. The Electronics and Communications Section of the Institution of Electrical Engineers (U.K.) is responsible for the organization of the conference.

Utility Management Workshop

The Ninth Annual Utility Management Workshop will be held at Columbia University, Harriman, New York, July 24-August 5. The objectives: "to enable a group of Utility executives to study the job of top management in the Utility Industry and to develop . . . workable solutions to the executive training problems in their own companies."

Proposed Conference on Electrical Engineering Education

September 1960 will see 100 persons, 75 of them Americans and 25 non-Americans, convene at Syracuse University, New York, for an International Conference on Electrical Engineering Education.

1960 National Die Casting (U.S.) Exposition

The First National Die Casting Exposition and Congress will be held in the Detroit Artillery Armory, November 8-11, 1960. Sponsored by the Society of Die Casting Engineers, the exposition will concentrate on the rapidly expanding die casting field.

Institute of Radio Engineers

The Fifth Institute of Radio Engineers' Canadian Convention and Exposition will take place in Toronto, in October 1961. An expanded technical program and increased industrial participation will be allowed by postponing the exposition for a year.

Petroleum Geologists (U.S.)

The American Association of Petroleum Geologists has elected Dr. Ben H. Parker, president of the Colorado School of Mines Board of Trustees, to its presidency.

Consulting Engineers of Canada

The Association of Consulting Engineers of Canada recently elected the following to office: R. R. Duquette, Montreal, president; John H. Rose, Toronto, vice president; James A. Kearns, Montreal, secretary-treasurer; and J. Murray Muir, executive secretary.

American Meteorological Society

The American Meteorological Society, Boston, Mass. recently celebrated its 40th anniversary. Dr. Thomas F. Malone, director of research for The Travellers Insurance Companies, Hartford, Conn., was elected president of the society for the two-year term 1960-61. Honorary Memberships were bestowed upon Sir Edward Appleton, University of Edinburgh; Prof. Andrei N. Kolmogorov, Moscow State University; and Dr. Theodore von Karman, NATO, Paris.

Astronautical Society

The Astronautical Society of Canada, Montreal, heard Professor Hubert Reeves, astrophysicist, University of Montreal, speak on "Spatial Erosion, Comets and Meteorites" on January 13.

Canadian Electrical Council

Canada's Electrical Day was celebrated in Winnipeg February 11 with meetings of the Canadian Electrical Council and the Electrical Bureau of Canada; a luncheon addressed by Mr. I. F. McRae, chairman of the board of Canadian General Electric; and conducted tours of the electrical displays at the Hudson's Bay Company. The Canadian Electrical Council, the Manitoba Electrical Association and the Electric Service League of Manitoba were joint sponsors.

Toronto Quality Control

The Toronto Quality Control Society (Toronto Section of the American Society for Quality Control) held its Seventh Annual All-Day Forum at the University of Toronto March 5. Sessions included a basic training course in statistical quality control, a series of lectures and a panel discussion on quality control applications in industry.

Canadian Electrical Association

All sections of the three Canadian Electrical Association divisions, Western Zone, will hold meetings at the MacDonald Hotel, Edmonton, March 21-23.

(Continued on page 125)

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Pressure Treated Foundation Piling

Modern water filtration plant at Edmonton, Alta., supported on "CCC" timber piling — shown at top during installation.

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DIVISION OF DOMINION TAR & CHEMICAL COMPANY, LIMITED

• CANADIAN DEVELOPMENTS

(Continued from page 112)

to the mutuol sotisfoction of the upstreom ond downstreom countries.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 5

The payment of a lump sum or periodic amount as may be agreed upon would, of course, be subject to the authorization of such payment by the Congress of the United States. Request for such authorization could be presented to the Congress for consideration as soon as a definite arrangement between the two countries became available as a basis for the request.

FLOOD CONTROL PRINCIPLE NO. 6

In the event of the downstreom country requesting speciol operotion for flood control of storoge included in the ossured plon of operotion, beyond the type of operotion provided for in such ossured plon, the upstreom country should be compensoted for ony loss of power which moy result therefrom. In the event of the downstreom country requesting the operotion, for flood control, of storoge not included in the ossured plon, the upstreom country should similiorly be compensoted for ony loss of power which moy be sustoined by the upstreom country ond in oddition should be poid on the bosis of holf the domoges prevented by the operotion of the storoge in question.

DISCUSSION OF FLOOD CONTROL PRINCIPLE NO. 6

This principle is included to provide for emergency operations to meet unusual flood producing conditions not covered in the assured plan of operation discussed under Principle No. 1. As long as operations for flood control remain in conformity with the assured plan of operation, there would be no compensation beyond that provided for in the other power and flood control principles.

If, however, unusual flood producing conditions should occur and, at the request of the downstream country, the upstream country should draw down its storages included in the assured plan to a greater extent or at a different time or in any manner not provided for in the assured plan of operation, the downstream country should compensate the upstream country for the loss of power sustained in providing the additional flood protection. That is, if such action caused a loss of power as compared with the results that would have been possible by adhering to the assured plan of operation, then the upstream country would be reimbursed for the loss of power at its plants and for the decrease in its share of power in the downstream country's plants.

The reimbursement could be either in cash or in power as might be mutually agreed upon.

In any event, the downstream country should give assurances that it would furnish sufficient power to meet minimum load requirements of the upstream country if the loss of power were so great as to adversely affect the upstream country's ability to meet the loads from its own resources.

The foregoing arrangements will apply also to upstream storage not in the flood control plan but which is operated in response to the request of the downstream country to give emergency relief. In this case, however, the downstream country should, in addition to the compensation to the upstream country for power loss, make a payment to the upstream country on the basis of half the damages prevented.

Signed at Washington this twenty-ninth day of December 1959.

Eugene W. Weber
A. G. L. McNaughton
Francis L. Adams
J. Lucien Dansereau
D. M. Stephens

• OTHER SOCIETIES

(Continued from page 123)

NRC Conference on Muskeg

A Muskeg Research Conference, organized by the Associate Committee on Soil and Snow Mechanics of the National Research Council's Division of Building Research, will be held on April 20-21 in Calgary. The over-all theme will be "Muskeg in Relation to Northern Development".

1960 Nuclear Congress (N.Y.C.)

The 1960 Nuclear Congress is to be held at New York City's Coliseum, April 4-7. A total of 57 technical papers will be presented during the four-day session, concerning Reactor Problems, Environment Problems, Materials and Components, Nuclear Standards, Isotopes and Radiation Processing. The Sixth International Atomic Exposition will be held in conjunction with the congress at the Coliseum.

Chemical Institute—AECL Symposium

A Nuclear and Radio-Chemistry Symposium will be held at the Chalk River laboratories of Atomic Energy of Canada September 6-8 under the joint auspices of the Inorganic Chemistry Division of The Chemical Institute of Canada and AECL. Participants are asked to submit abstracts of up to 11,000 words by June 15.

• DISCUSSION

(Continued from page 99)

must be made in the navigation channels to provide the full 27-foot depth at all times. Channel grades were based primarily on a profile showing the minimum water surface levels along the river for the critical monthly mean Lake Ontario levels and outflows under a method of regulation and the extra depth to provide for negative seiches was estimated from past records. Table I indicates as percentage of occurrences the degree of deviation at three locations during the navigation season. It also indicates the cumulative effect of a seiche as it progresses downstream from Lake Ontario.

With the dams completed at Iroquois, Long Sault and Barnhart Island, the seiches would be reduced owing to the increased area of the river surface. Based on studies made primarily by the St. Lawrence Seaway Authority it was finally agreed that an allowance of 2 ft. above Iroquois Dam and 1 ft. for those channels below Iroquois Dam would probably be sufficient. Experience to date indicates that this allowance is reasonably accurate.

Discussion by D. M. Ripley

The problem of river control during construction of the St. Lawrence Power Project was undoubtedly made more exacting, if not more difficult, by the knowledge that riparian interests around Lake Ontario have been extremely sensitive to adverse lake stages. This fact was well demonstrated by the objections raised by shore property owners during the high water level period of 1952. The approval of the International Joint Commission for the project was given in October of that year and the St. Lawrence River Joint Board of Engineers, appointed by the government of Canada and the United States pursuant to the Order of Approval, was keenly aware of the need for maintenance of pre-project conditions within close limits during construction. Their concern over a unified control of river works, as pointed out by Mr. Henry, is, therefore understandable. No less important during the construction period was the safeguarding of downstream navigation and power interests, which are more quickly affected by changes in river flow than the Lake Ontario interests. For example, a change in river flow of 20,000 cfs results in a change in the level of Montreal Harbour of about 1 ft., whereas this change in flow would have to be sustained for a period of four months to change the level of Lake Ontario by that amount.

The choice of Mr. Henry as River Control Engineer was a fortuitous one —the record speaks for itself.

Construction of the St. Lawrence Power Project is virtually complete but the control of the levels and outflows from Lake Ontario must be continued. For the time being the regulation "rule" is the maintenance of pre-project conditions. In the near future, a more appropriate plan of regulation will be instituted which will decrease the range of stage on Lake Ontario to the benefit of shore property owners, modify the outflows to increase the dependable power output at St. Lawrence River generating stations and safeguard downstream interests, including those of navigation. When such a plan of regulation is put into operation the experience gained on river control during construction will point the way to the most effective means for observance of the criteria of regulation.

NEWS OF THE BRANCHES

Assumption University

William Pulleyblank, S.E.I.C.,
Correspondent

The Border Cities Branch of E.I.C. invited the Student Members to their dinner meeting on January 20. A very friendly relationship was established between the Members and Students.

On January 28, 29, 30 and 31, the third year Student Members travelled to Hamilton and Toronto to visit Proctor & Gamble, Stelco, Westinghouse and the University of Toronto. This field trip will undoubtedly turn out to be the highlight of this year's activities.

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

The Annual General Meeting of the Baie Comeau Branch was held on November 6, 1959, at the Manoir Comeau and the following officers were elected for the coming year: chairman, G. W. Scott; secretary, Louis Tellier; treasurer, John O. Down; executive committee, P. Suttie, M. Pope, A. H. C. Carson; Labrieville representative, G. Labossiere; member emeritus, E. Bodmer.

Before relinquishing office, Mr. Bodmer, retiring chairman, gave a review of the past year's activities which included two field visits and five papers by distinguished visiting speakers. Overall branch membership stood at 71, including 25 branch affiliates. The past year has been a most successful one and Mr. Bodmer paid special tribute to the work done by the Branch Secretary, Louis Tellier, Jr.E.I.C.

Belleville

Wilburt Canniff, JR.E.I.C.,
Correspondent

Mr. H. R. Chipman, new product development manager at the Dominion Rubber Company, Kitchener, was the speaker at the branch meeting February 8. His topic: Engineering Applications of Re-inforced Plastics. He explained that although the first re-inforced plastics were produced about ten years ago, adequate design data was sparse. Mr. Chipman discussed the various re-inforcing materials and the properties of the resins used. The major resin in this field, polyester, is fabricated by hand lay-up, pressure bag molding, vacuum draw molding and matched metal molding.

Mr. J. J. Hanna, president of the E.I.C., was guest speaker at a stag dinner held in his honour at the Belleville Shrine Club, Monday, January 25. Approximately 50 Quinte District E.I.C. and A.P.E.O. members were there to hear Mr. Hanna, who recently retired as manager of the Calgary Oil Refinery, speak on the need to use but not abuse Canada's natural resources. He impressed upon the members the need for developing new processes and labour-saving equipment to keep our export prices down.

The president also announced that, starting with the February issue, The Engineering Journal was extending its circulation to all Professional Engineers.

Border Cities

W. A. Macdonald, JR.E.I.C.,
Correspondent

The Border Cities Branch Auxiliary has successfully completed its eighth year. Four interest groups are in action—mixed bowling, an afternoon bridge, and two evening bridge groups. The Annual Meeting, a dinner meeting, was held at Mario's February 3, 1959, and Mrs. St. Aubin spoke to the membership on "Ceramics". On March 17 a social evening and membership drive were held, resulting in a total membership of 82. Other events of the year included a family picnic, June 20; a luncheon at the Lakewood Golf Club, September 15; and a party given by the executive for Mrs. Lilian Robertson, secretary, Toronto office, November 17.

The executive for 1960, installed at a dinner meeting in the Palm Room at Mario's, February 2, 1960, is as follows: president, Mrs. H. J. Chapman; first vice-president, Mrs. J. W. Brison; second vice-president, Mrs. G. G. Henderson; recording secretary, Mrs. H. Bily; corresponding secretary, Mrs. E. T. Rivington; treasurer, Mrs. A. McCaw; publicity convener, Mrs. D. Servage; groups convener, Mrs. D. Osmun; councillors, Mrs. C. M. Armstrong, Mrs. J. Reid, and Mrs. E. Dykeman.

Participants in the Montreal Branch, Junior Section, Students' Night: *Back Row* (l. to r.): Messrs. Gantsheff, Philips, Benoit, Walker, Barcelow, and Kane. *Front Row* (l. to r.): K. Soosar, McGill; R. Lalencette, Ecole Polytechnique; M. Gagnon, Sherbrooke; and G. Desrosiers, Laval.

Calgary

Herbert Bailey, M.E.I.C.,
Correspondent

Mr. A. G. Martin, city planner for Calgary, discussed "Planning in a Changing Environment" at the Calgary Branch meeting January 21. He outlined the various universal and local forces that have been and are molding our present environment and pointed out that the last decade was not the only boom in Calgary. In fact, the sewers and water mains which were installed during the early boom of 1911-13 accommodated the city's expansion until 1953. At the legislative level, a completely new planning act gives the city wide authority in the enactment of zoning by-laws, development schemes, and planning boards. Mr. Martin suggested that the development of self-supporting urban centres which are closely linked but separated geographically from the main city will have to be seriously considered, and that this form of development was being tried in England. Mr. Martin closed in saying we should beware of the sceptic who says "It can't be done."

Cape Breton

Lloyd R. Boutilier, M.E.I.C.,
Correspondent

Members of the Cape Breton Branch at the January 28 meeting heard Mr. George Kirkpatrick of the exploration division of Imperial Oil talk on exploration and how and why geologists choose a prospective sight for oil drilling. Mr. Kirkpatrick, an expert in oil drilling who has been engaged in exploration work across Canada for 25 years, showed a film entitled "Search Unending" and displayed drill bits and small equipment. The meeting was quite informal, the better part of it an open discussion period relating to drilling procedures, findings and results in the Cape Breton area. The speaker was introduced by Mr. Brian Hansen of Imperial Oil and the vote of thanks was given by Mr. Rod Bradley, Dominion Steel and Coal.

Central B.C.

A. F. Joplin, M.E.I.C.,
Correspondent

On January 22, Mr. Edward Rohatynski, M.E.I.C., an engineer with the Consolidated Mining & Smelting Co., Kimberly, presented a paper to members entitled "Model Studies Leading to Modification of Waneta Dam", which he had given at the Western Technical Conference in Banff in October. At this first meeting of 1960 the year's program was discussed and field trips were proposed to see Cominco at Trail, B. C. and the power development at Cranberry Creek, Revelstoke.

Hamilton

Charles A. McCurdy, JR.E.I.C.,
Correspondent

The first meeting of the Civils Group of the Hamilton Branch, January 14, took the form of a panel discussion and a film on winter construction. Mr. Paul Goyette, Central Manufacturing & Housing, spoke on "Need for Winter Construction"; Mr. Hugh Connor, M.E.I.C., C. C. Parker & Associates, "Technical Aspects of Winter Construction"; Mr. Pat McNally, M.E.I.C., S. McNally & Sons, "Practical Solution to Winter Construction". Mr. W. A. Filer, Wagner, McCarger, Filer, was the moderator.

Kitchener

A. R. LeFeuvre, M.E.I.C.,
Correspondent

Mr. D. B. Redfern, senior partner, Proctor & Redfern, Consulting Engineers, Toronto, addressed the Kitchener Branch meeting on January 28. Speaking on pollution and sewage treatment in the Grand Valley, Mr. Redfern outlined the historical background of the pollution problem. He gave credit to the Water Resources Commission of Ontario for the vast improvement in facilities for sewage treatment in the last few years. Specific reference was made to the new or extended facilities at Elora, Waterloo, Kitchener, Preston, Galt and Brantford.

The new executive for 1960 was introduced as follows: councillor, L. J. R. Saunders; past chairman, W. J. Horner; chairman, A. H. Austin; vice-chairman, W. Bobbie; sec.-treas., C. G. E. Downing; directors, R. Dahmer, A. R. LeFeuvre, W. L. Bulmer, and M. H. Schmitt.

Fredericton

John M. Burrows, JR.E.I.C.,
Correspondent

Dr. G. V. Bull and Wing Commander E. A. Smith of the R.C.A.F. detachment at C.A.R.D.E. were guests of the Fredericton Branch January 25. Dr. Bull, who is superintendent of the aerophysics division at the Canadian Armament Research & Development Establishment, Valcartier, Que.. spoke on "Zero Physical Research Activities at C.A.R.D.E." He discussed the in-flight behaviours of various guided missiles, the temperature problems encountered with the various materials used, and the reaction of missile components under controlled, simulated flight conditions at C.A.R.D.E.

Wing Cmdr. Smith addressed the gathering on Project Look Out, where the R.C.A.F. at Ascension Island inspect re-entering missiles fired from Cape Canaverall, Fla., in cooperation with the U.S.A.F.

A formal presentation of the E.I.C. Prize to Ralph Francis for academic standing in his fourth year of civil engineering at U.N.B. was made by the

CANADIAN

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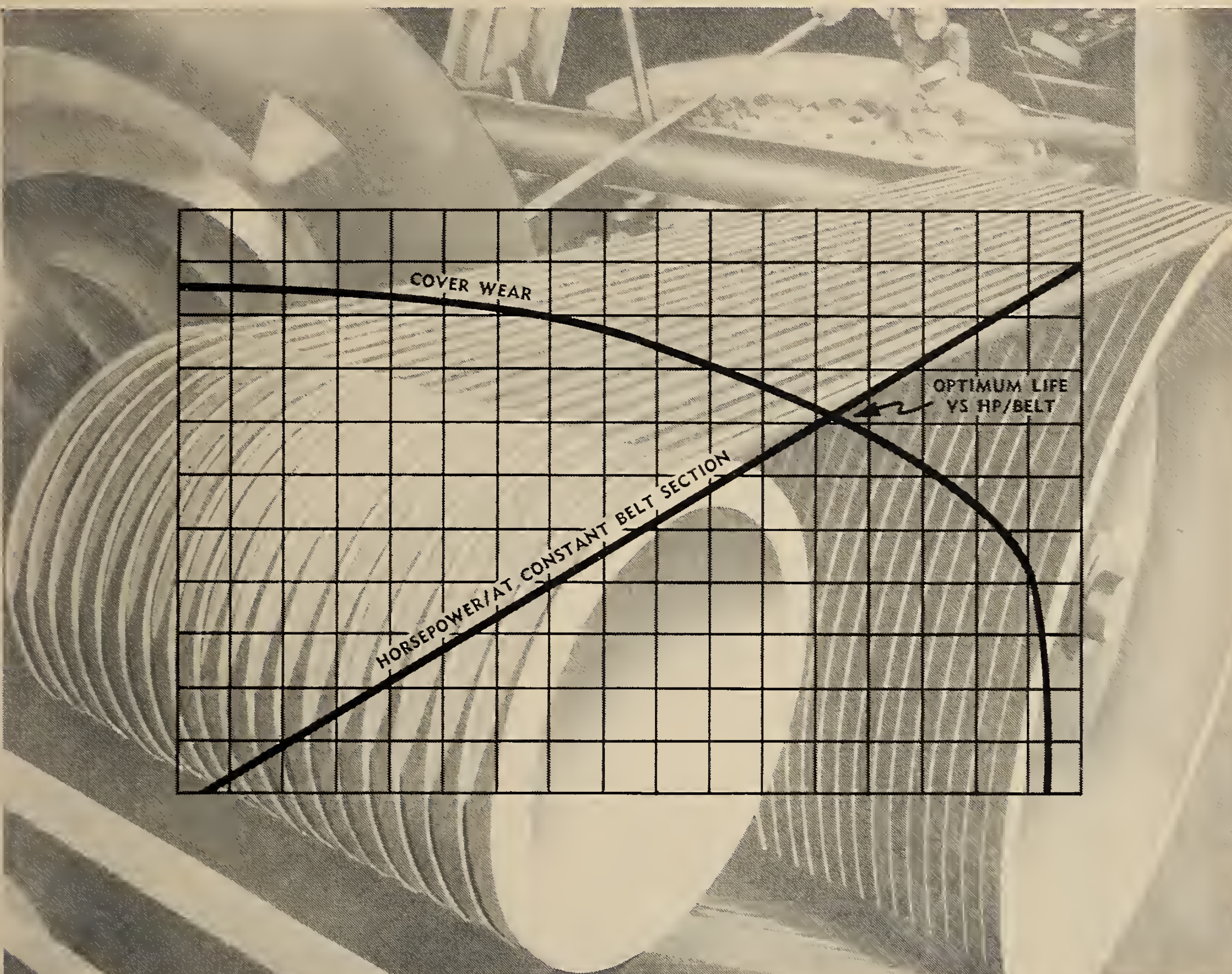

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immediate past chairman of the Fredericton Branch, Otis I. Logue.

Moose Jaw

T. L. Salmon, M.E.I.C.,
Correspondent

Mr. R. J. Wilson of the Saskatchewan Power Corporation discussed the Saskatchewan Boundary Dam Generating Station at the January 14 meeting of the Moose Jaw Branch. He dealt with the generating plant, the associated water storage dam, and the coal mining and handling facilities. Mr. Wilson made special reference to equipment where design was peculiar to the location or kind of coal in question. The membership was honored to have the E.I.C. Western Field Secretary, Col. A. C. M. Davy, at this meeting, who gave an account of Institute activities.

Niagara

E. C. Little, M.E.I.C.,
Correspondent

A joint meeting of the A.I.E.E., E.I.C. and A.P.E.O. was held on January 28 at the Park Hotel, Niagara Falls, Ont. Mr. H. A. Smith of the Hydro-Electric Power Commission of Ontario, gave a very interesting address on "Modern Steam Generating Stations". The next meeting on February 20 will be Junior Engineers' Night.

Nipissing and Upper Ottawa

R. D. Christie, JR.E.I.C.,
Correspondent

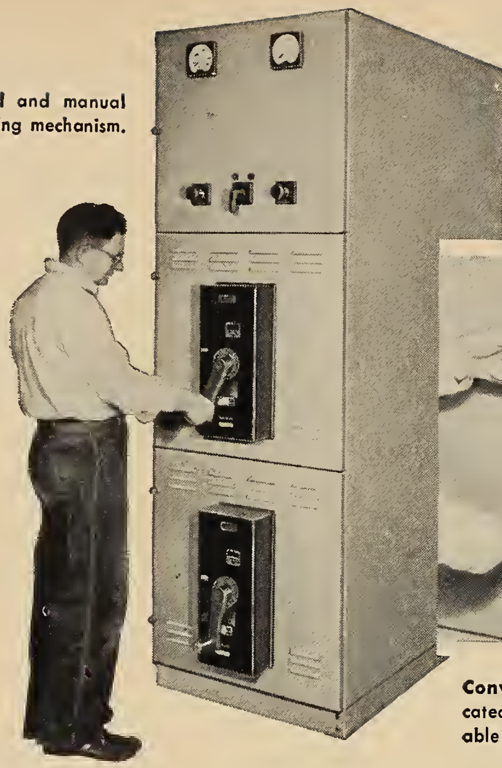
Lt. Col. R. J. Cassidy, C.B.E., M.E.I.C., project supervisor at Defence Construction Ltd., North Bay, Ont., spoke briefly on the organization of his company at the January 13 meeting at Sturgeon Falls, Ont. Col. Cassidy discussed the many varied projects undertaken by the corporation since 1950 and spoke at some length on his experience during the construction of Camp Gagetown.

A short discussion on the subject of a university in the Northern Ontario area followed. At least two groups are currently planning to found a college or university. The Branch passed a motion declaring our interest and willingness to help any group who might sponsor a college for the benefit of the people in our area.

Peterborough

D. B. A. Chase, JR.E.I.C.,
Correspondent

Peterborough Branch members of E.I.C. held a Viking Ball at the Empress Hotel January 15. Retiring Chairman Howard Powell opened the ball, which Members Roy Olsen and Vino Aare had organized. The new chairman of the branch, Robert Allemang, was introduced as well as the 1960 executive including Robert Aspinall, Dick Armstrong, Derek Chase, Jim Hooper and Jack Scrimgeour.



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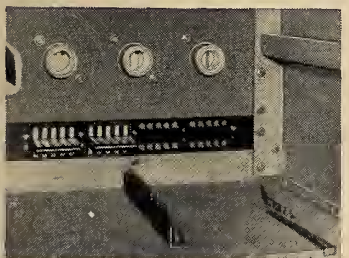
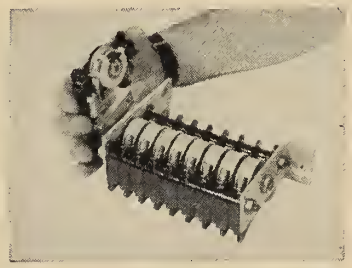
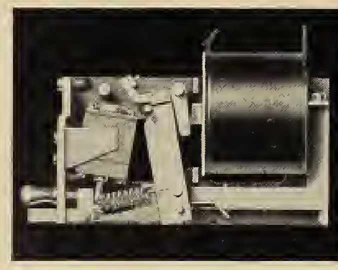


Safety—*(a)* interlock prevents movement of closed breaker; *(b)* latch prevents rocking past disconnect position.



Flexibility—each stage of auxiliary switch assembly is individually adjustable without disassembly.



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CANADIAN ALLIS-CHALMERS

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● BRANCH NEWS

Lethbridge

P. A. Harding, JR.E.I.C.,
Correspondent

Mr. R. J. B. McNally, plant engineer with the North-West Nitro Chemical Plant, Medicine Hat, Alta., gave a talk to Lethbridge members on construction and operation of the nitro-chemical plant on January 16. The plant, completed in 1956, produces primarily the chemical fertilizers ammonium phosphate and ammonium nitrate. It uses about 400 tons of phosphate rock (obtained from Montana) per day, about 135 tons of sulphur (Pincer Creek, Alta.), and approximately 12 million cubic feet of gas from the Medicine Hat area of Alberta. Air and water also go into the fertilizer production, and the water is brought from the South Saskatchewan River by 16-in. line directly to the company's own water treatment plant.

Toronto

D. R. Abbey, M.E.I.C.,
Correspondent

Dr. Arthur Kantrowitz, director, Avco-Everett Research Labs, Boston, reviewed the field of space flight using unmanned equipment and discussed the challenges which this expanding field offers the different branches of engineering at a meeting of the Toronto Branch January 14.

Reports were received from the Electrical and Power Sections of the branch and the Joint Area Committee (Civil). The meeting was turned over to the 1960 chairman, Mr. A. M. Toye. Dr. R. R. McLaughlin, dean of the University of Toronto's engineering faculty, is the new branch vice-president.

The Toronto Branch Student Activities Committee, chaired by Mr. Les Hutchinson, recently arranged a tour of the Ford Motor Company of Canada, which was attended by 115 students. Host for the tour was Mr. Jim Ronson, manager of Ford's Oakville Operations. Following the tour there was a film on the Dearborn Research Center and a question-and-answer session.

The Joint Area Committee (Civil) held an extremely interesting panel discussion entitled "Economy or Good Construction" on January 21. Moderator of the panel was Professor E. A. Allcut and members included Mr. Harry B. Kohl, architect, and Messrs. Harvey Self, C. D. Carruthers, and C. E. Potter, all engineers, but respectively representing the viewpoints of owner, consultant and contractor.

On January 27, sixty members of the Power Section heard a paper by H. A. Smith, assistant general manager, Engineering, H.E.P.C. of Ont., and W. F. Allen, Jr., mechanical engineer, Stone and Webster Canada, entitled "Concept and Salient Design Features of Two Modern Thermal Power Stations". The two stations discussed were the R. L. Hearn Generating Station Extension and the Lakeview Generating Station.

Vancouver

C. H. White, S.E.I.C.,
Correspondent

The Vancouver Branch of E.I.C. has published its Professional Development Program for 1960, following the theme "Beyond the Engineering Horizon—the Arts". The sessions include: "The Utopias", Feb. 3; "Greek Archeology", Feb. 10; "What do we know about Shakespeare?", Feb. 17; "Music—A Reflection of the Times", Feb. 24; "Philosophy", March 2; "B.C.—The Writing of its History", March 9; "Geometry Yesterday and Today", March 16; and "Russian Culture", March 23.

Vancouver Island

W. N. Tivy, M.E.I.C.,
Correspondent

Mr. R. R. McLeod, senior petroleum engineer, petroleum and natural gas branch of the Department of Mines, B.C., was the guest speaker at the January 20 meeting. His subject: "Oil and Gas Development in B.C.". Mr. McLeod dealt with the geography and general history of the development of the northeastern portion of the province.

On January 23 members visited the Victoria Machinery Depot to inspect the new B.C. government ferry, M. U. Sidney. The ferry will commence operation between Sidney (about 18 miles north of Victoria) and a point south of Deas Island Tunnel on the mainland this year.

Winnipeg

P. M. Abel, JR.E.I.C.,
Correspondent

Brig. A. B. Connelly, C.B.E., C.D., chief of the engineering division, Northern Administration Branch, Department of Northern Affairs and Natural Resources, addresed the membership on January 28 on the subject of "Northern Construction". Brigadier Connelly discussed various unique aspects of construction in the Far North and dealt with roads, bridges, airstrips, docks, reservoirs, water supply, sewerage, power houses, utility ducts, but put main emphasis on buildings and foundations and permafrost problems. The talk was supplemented by 150 colour slides. The speaker was introduced by Lt. Col. H. D. Berry, Command Engineer, Prairie Command, and thanked by Prof. W. F. Riddell of the University of Manitoba.

This was the Annual Meeting of the branch and the slate of officers was announced: chairman, W. L. Wardrop; vice-chairman, R. E. Chant; members of the executive, J. B. Striowski, C. S. Landon, L. A. Bateman, D. Chappell, and T. E. Weber; councillors, S. Barkwell, N. M. Hall; E.I.C. nominating committee, W. D. Hurst; general papers chairman, G. C. Marsh; E.I.C. university representative, J. P. C. McMath; membership chairman, L. E. Poyser; electrical section representative, A. S. Williams; civil section representative, I. B. Henderson; student section representative, D. N. Brown; branch reporter, P. M. Abel; vice president, zone A, C. V. Antenbring.

(Continued on page 138)

● BRANCH NEWS

(Continued from page 134)

Montreal

(Junior Section)

R. D. Hatfield, S.E.I.C.,
Correspondent

On February 5, the Montreal Branch sponsored its annual students' night involving all four of Quebec's major engineering schools, Laval, Sherbrooke, Ecole Polytechnique and McGill. The meeting was chaired by Mr. Roger Miller, of Ecole Polytechnique, and organized by Mr. R. D. Hatfield, of McGill. The four contestants were Mr. K. Skooner, "Rolling Lift Bridges", first prize, $50; Mr. R. Lalancette, Ecole Polytechnique, "Ice Formation", second prize, $35; Mr. M. Gagnon, Sherbroke, "Tidal Generating Stations", third, $20; and Mr. G. Desrosiers, Laval, "Hydraulics", fourth, $10.

Two of the papers were in French; the other two, in English. Judges were Mr. Gantsheff, Ecole Polytechnique; Mr. Philips, past chairman, Montreal Branch; Mr. Barcelon, C.P.E.Q., and Mr. Kane, Dominion Bridge.

Mr. Hance Legere, director of technical services for E.I.C., addressed the meeting after the judging.

Kootenay

I. Waterlow, JR.E.I.C.,
Correspondent

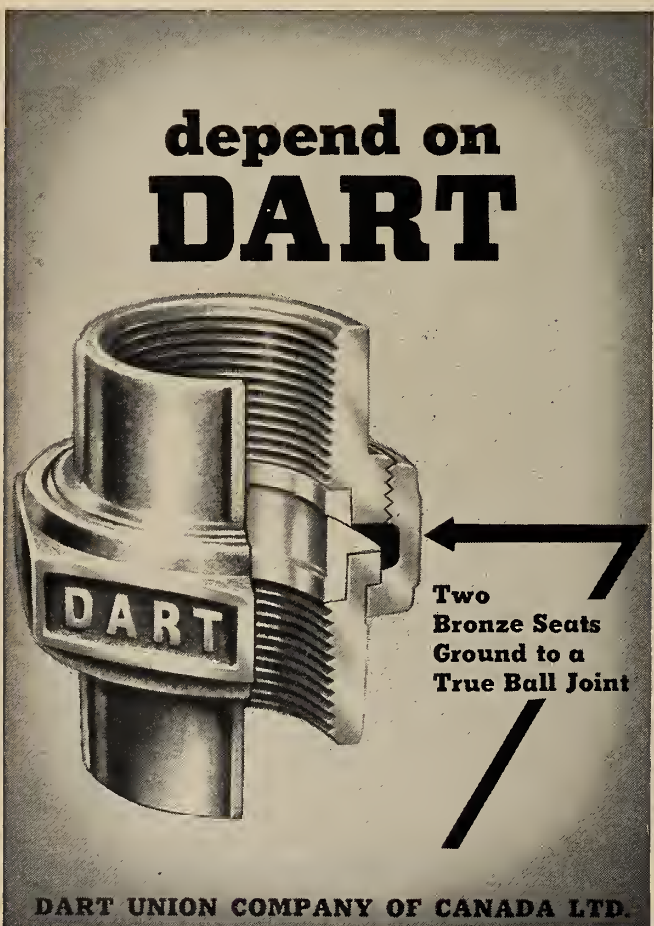
"Trends in Fertilizer and Chemical Industries" was the subject of a talk given by Mr. E. A. Colls, manager, fertilizer division, Cominco, to the Kootenay Branch on January 18. Mr. Colls indicated that the fertilizer and heavy chemical industry had grown in relation to population growth and discussed the changes in types of fertilizers required.

Sarnia

Paul Donato, M.E.I.C.,
Correspondent

Mr. V. J. Bakanowski, principal project engineer, and Mr. R. N. Boyd, supervising engineer, both of Dupont of Canada, Montreal, gave a joint talk, "Technical Uses of Computers in the Chemical Industry", at the January 20 meeting.

Dr. H. F. Waldron of the Defence Research Board was guest speaker on February 23 on the subject of missiles.



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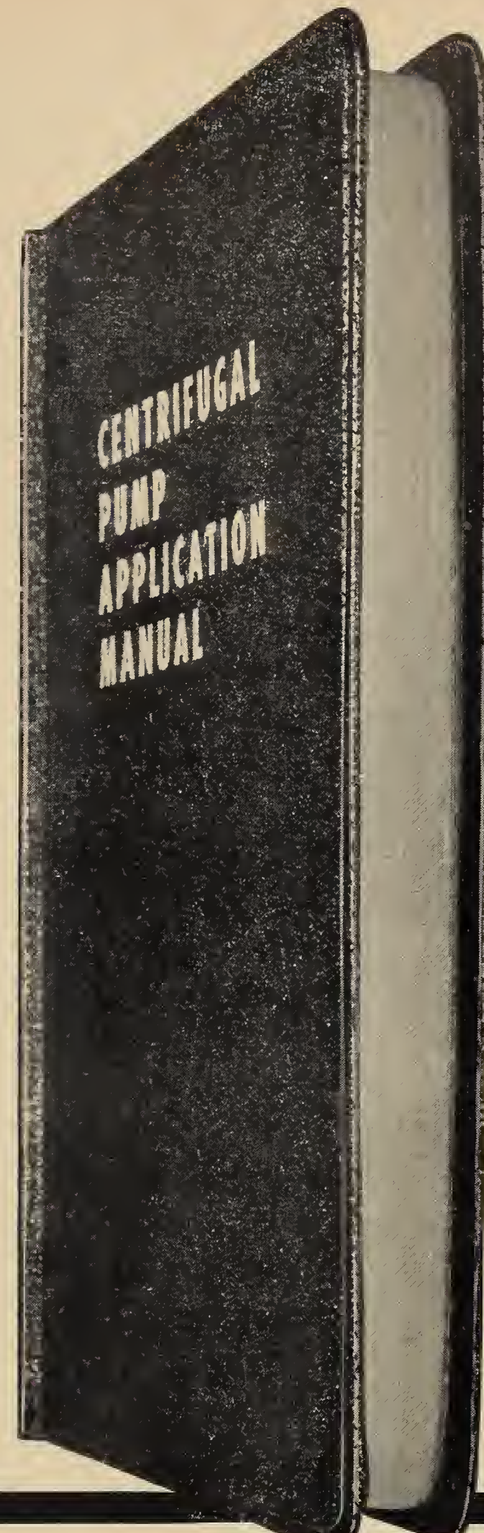

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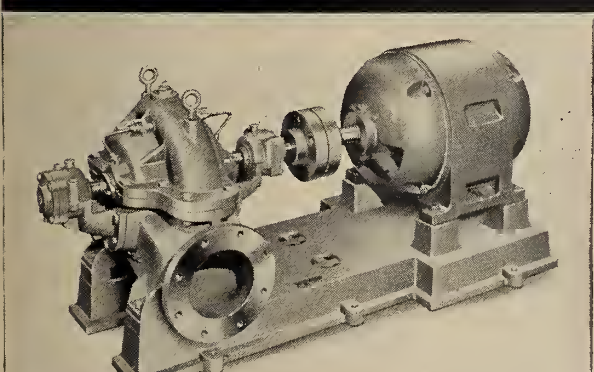

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NEWS OF THE

Associations and Corporation

C.P.E.Q. President Says Young Engineers Must Specialize in New Branches

The field for engineers in Canada will be wide open at least to the end of this century, W. J. Riley, M.E.I.C., president of the Corporation of Professional Engineers of Quebec, stated at a press conference in Montreal February 17. The exodus of Canadian engineers to the U.S.A., he pointed out, suggests only that these young engineers have not specialized adequately to find employment in the newer, and increasingly important, fields of engineering. The approximate $1000 difference in salary, he stated, is a constant discrepancy in engineering salaries regardless of position, so that the senior engineer is not greatly tempted by financial benefits to emigrate.

Increased university enrolments do not mean that employment in Canada will be more difficult to find, stated the president. It only means that students will have to think early about what industry is demanding and specialize accordingly. Electronics, electro-mechanics, and nuclear engineering are the fields which Mr. Riley sees as the key fields to engineering's future expansion.

Mr. Riley also stressed the importance of the engineer's professional status. As the great majority of engineers become employee-engineers it is necessary for them to establish their professional status so that, in a business, they are treated in the same light as the company doctor or company lawyer.

B.C. Association Holds Annual Honours and Awards Luncheon

The Association's annual Honours and Awards Luncheon honoured five Life Members of the Association: A. E. Carter, Sutton, Quebec; W. C. Douglass, Seattle, Washington; Stanley Gary, Vancouver; H. K. Qually, New Westminster; and J. Sinclair, Vancouver. At the same time Retiring President R. E. Wilkins, M.E.I.C., announced the winners of special awards.

The Letson Memorial Prize for the best report or thesis on mechanical engineering submitted in support of an application for registration was awarded to Paul Koeller. K. Teng and H. Arndt, both students in the Faculty of Applied Science, University of B.C., won this year's Ingledow Prizes.

A.P.E.O. Makes Secondary School Science Teaching Award

Harold L. Eubank, vice-principal of Etobicoke Collegiate Institute in Metro Toronto has been chosen Ontario's outstanding mathematics and science teacher of the year by the Association of Professional Engineers of Ontario.

The award, established last year, recognizes the contribution made to the engineering profession by the secondary school teacher in mathematics and science. The Ontario Secondary School Teachers Federation is responsible for the selection of the award winner.

Mr. Eubank is a former president of the Science Teachers Association of Ontario and is co-author of two school text books, *Basic Physics for Secondary Schools* (used in Grade 11 of the Ontario schools) and *Physics for Secondary Schools* (authorized for use in Alberta).

A.P.E.O.'s Retiring President Predicts Bright Decade for Engineering

In his address to over 1,000 professional engineers attending the recent annual meeting of the Association of Professional Engineers of Ontario A. W. F. McQueen, retiring president of the association, stated that there was every reason to expect a greater pattern of technological progress during the 1960's.

Calling upon the engineering profession to prepare itself to meet the future's "grave responsibilities", Mr. McQueen referred to a statement made recently by Dean J. W. Hodgins of McMaster University, Hamilton, that "whether we like it or not, many of the decisions which most affect our lives in the next decades are likely to be made by scientists or engineers". Mr. McQueen also pointed to the co-operation being offered by the Association to the universities in advancing engineering education.

"In this matter of engineering education, the universities and the Association need each other's help," he said, adding that he believed this was the A.E.P.O.'s biggest task. He noted that 115 engineers had participated in the new correspondence courses instituted last year by the University of Toronto for registered professional engineers. These courses included English Composition, English Literature, Economics and Business Organization. Next year more subjects are to be added to the correspondence course program.

The retiring president called upon the membership of A.P.E.O. to support the recently established Professional Engineers' Foundation for Education which provides direct financial assistance for both undergraduate and graduate students in engineering.

Manitoba Association Elects Officers

W. L. Wardrop was re-elected president of the Association of Professional Engineers of Manitoba at their Annual General Meeting, January 23, in Winnipeg. Prof. R. E. Chant was elected vice-president; Dr. C. S. Landon, secretary and registrar. Others elected to the Council of the Association are Prof. O. Marantz, B. Chappekk, and T. E. Weber.

Closer Co-operation for Engineers and Architects

Senior officers of the Royal Architectural Institute of Canada and the Canadian Council of Professional Engineers met in Ottawa recently to study ways and means of improving the quality and efficiency of architectural and engineering services through closer cooperation between the two professions.

It was agreed to establish a joint committee of both bodies at the national level to: develop better understanding between members of the two professions; assist in maintaining and developing proper relations between Architects and Engineers in the best interest of the public they serve; to provide a means of co-operation on problems which are of interest to both groups and national in scope.

LIBRARY NOTES

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

BASIC AUDIO

Another of Rider's easily understood "picture book" courses, requiring only a basic knowledge of electricity for its comprehension. It explains the part played by each component in an audio system, and the electronics and circuit theory needed to assemble or operate a hi-fi or audio reproducing system.

The topics covered include: sound and acoustics; microphones; loudspeakers; impedance matching; resonance; audio response curves; transistors; frequency response; phase-splitting circuits; feedback; power supply; shielding; etc. (N. H. Crowhurst. New York, Rider, 1959. 3 vols. $2.90 each. $8.70 set.)

SURFACE DEFECTS IN INGOTS AND THEIR PRODUCTS, 2nd. ed.

Recommended definitions for defects occurring in ingots and certain semi-finished and finished products, compiled in an attempt to standardize the terms used. The definitions, which are clearly illustrated, are divided into three sections: surface defects in the ingot; defects in finished products arising from ingot defects; processing defects. (Ingot Surface Defects Sub-Committee of the British Iron and Steel Assoc. London, Iron and Steel Institute, 1958. 58 p., 25/-.)

*HANDBOOK OF INDUSTRIAL RESEARCH MANAGEMENT

This volume provides a guide for the organization, evaluation, and control of industrial research. For those in top management the book can be a yardstick and a guide to controlling and evaluating this costly operation; for directors of research, administrative problems are dealt with; for their executive directors, the day-to-day details and responsibilities are presented; and for financial executives there are papers on accounting and budget control of the research function. The final chapter discusses government contracts. (Ed. by Carl Heyel. New York, Reinhold, 1959. 513 p., $12.00)

*SPACE TECHNOLOGY

A thorough exposition is given of the fundamental physical principles of very long-range ballistic vehicles, stressing the quantitative relations that are most useful for space flight. In addition to a particularly thorough discussion of ballistics and flight dynamics, coverage is given to propulsion, communications and guidance, man in space, and the scientific uses of space. The five hundred selected references given provide a guide to the significant literature in this field. (Ed. by H. S. Seifert. New York, Wiley, 1959. Various pagings. $22.50.)

*NUCLEAR FUEL ELEMENTS

Papers presented by U.S. and European scientists at the First International Symposium on Nuclear Fuel Elements (January 1959) form the basic part of this book on the development, design and fabrication of nuclear fuel elements. Topics covered include element standardisation and fabrication cost-analysis, as well as the physical and operational characteristics of elements. Appendices offer typical specifications and an extensive bibliography. (Ed. by H. H. Hausner and J. F. Schumar. New York, Reinhold, 1959. 409 p., $12.50)

*FOUNDRY ENGINEERING

A comprehensive approach to the engineering principles and methods of foundry operation is presented. Up-to-date coverage is given for such topics as refractories, casting processes, sand reclamation and control, welding, and heat treatment. A feature of the book is the treatment of solidification and structure of cast metals, and of correct gating and risering of castings. Numerous three dimensional drawings help to clarify the text. (H. F. Taylor, and others. New York, Wiley, 1959. 407 p., $9.75.)

*CHEMICAL PROCESS PRINCIPLES: PART II, THERMODYNAMICS, 2nd. ed.

The fundamental principles of thermodynamics are presented with particular attention to generalized methods. In this volume the material contained has been revised to reflect recent technological advances dealing with such aspects as improved generalized tables of state and thermodynamic properties, thermodynamics of fluid flow including the cases of compressible fluids at sub- and supersonic velocities, detailed cycle analysis of modern vapor turbine power units, and cycle analyses of modern internal combustion engines including free-piston gas turbines, turbojet, ramjet, and rocket engines. (O. A. Hougen and others. New York, Wiley, 1959. 1072 p., $9.75.)

*HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL, VOLUME 2

The second of three volumes, this volume provides a comprehensive coverage of the design and use of analog and digital computers and data processors. Some of the features of this handbook are chapters which deal with computer terminology, magnetic core and transistor circuits, advanced programming, and unusual computer systems involving operational digital techniques, combined analog-digital computer systems, and turing type computers. (Ed. by Eugene M. Grabbe and others. New York, Wiley, 1959. Various pagings. $17.50.)

*NOMOGRAPHY, 2nd. ed.

A text that provides a working knowledge of the basic theory and construction of charts involving straight line scales, curved scales, and combinations of the two. In this edition new chapters are presented on circular nomograms, projective transformations, and the relationship between concurrency and alignment nomograms. In addition there is a considerable expansion of the material included in the previous edition and a number of new problems and examples are introduced. An appendix includes 58 nomograms from various scientific fields. (A. S. Levens. New York, Wiley, 1959. 296 p., $8.50.)

*SYMPOSIUM ON PARTICLE SIZE MEASUREMENT

Representing current thinking in the field of particle size measurement, many aspects of this type of measurement are discussed, including sieves, mechanical methods of separation, electronic methods of measuring, and photo-electric procedures. (Philadelphia, American Society for Testing Materials, 1959. 310 p., $6.25 S.T.P. 234.)

*CALCUL A LA RUPTURE ET PLASTICITE DES CONSTRUCTIONS

This translation from the Russian deals with the calculation of the breaking points of structures based on the theory of plasticity. The elastic limits of both statically determinate and indeterminate structures are defined, as are the laws of linear and non-linear deformation under different types of stress. Essential theory is given for calculating the plastic limits of beams, plates, etc.; and the book concludes with the general principles for determining tolerances and safety coefficients in construction work. (A. R. Rjanitsyn. Paris, Eyrolles, 1959. 284 p., 4400 fr.)

*AMENAGEMENTS HYDROELECTRIQUES

Following a discussion of hydroelectric equipment within its historical and geographical framework, the author examines the fundamental principles of hydroelectric structures, the various types of dams, related structures (spillways, gates, conduits, intakes), and turbines and pumps. An appendix discusses the use of scale models in the determination of experimental values and the factors that influence the magnitude of these values. (R. Ginocchio. Paris, Eyrolles, 1959. 480 p., 3500 fr.)

*BARRAGES MOBILES ET PRISES D'EAU EN RIVIERES

A study of movable dams and water-intake systems in rivers, covering such aspects as rate of water flow, water level, drift of alluvial deposits, and flow through sluices. The construction of sluice gates, coffer dams, water- tapping devices, and sand and gravel filtering equipment is also discussed. (M. Bouvard. Paris, Eyrolles, 1958. 238 p., 2600 fr.)

*THE CATHODE-RAY TUBE AND ITS APPLICATIONS, 3rd. ed.

The use of the cathode ray tube in oscillography is stressed in this volume which provides a guide to the operation and use of the tube as a versatile measuring instrument. Among the topics considered are power supplies, amplifiers, time and frequency bases, photographic recording, and transducers. Also considered are mechanical, electrical, and nuclear applications. While the sections dealing with applications and associated circuits have been considerably expanded in this edition, only a superficial coverage is given to the theory and design of the electron gun. (G. Parr and O. H. Davie. Toronto, Ryerson, 1959. 433 p., $10.00.)

*THERMODYNAMIC AND TRANSPORT PROPERTIES OF GASES, LIQUIDS, AND SOLIDS

In addition to reviewing and evaluating the subject as a whole, the forty-two papers included report a large amount of new data as well as recent techniques. The papers discuss transport properties from the standpoint of theory and experiment, the thermodynamic properties of liquids and gases, PVT data and equation of state, thermodynamic properties of boron compounds, high temperature transport properties of metals and ceramics, and high temperature thermodynamic properties of gases. These papers were presented at the Symposium on Thermal Properties held in February 1959. (New York, American Society of Mechanical Engineers, 1959. 472 p., $12.50.)

*SEMICONDUCTORS

A comprehensive account of the physics of semi-conductors is given along with a brief review of their applications. The author discusses energy levels in crystalline solids; impurities and imperfections in crystals; carrier concentrations in thermal equilibrium; electron transport phenomena; thermal, optical, and high-frequency effects in semi-conductors; diffusion of electrons and positive holes; measurement of semiconductor properties; and the properties of the various types of semiconductors known. The treatment is based on the "effective mass" concept, and only a brief and elementary account is given of the quantum theory underlying the motion of electrons through a crystal. (R. A. Smith. Toronto, Macmillan, 1959. 494 p., $11.25.)

*EXTRACTIVE METALLURGY

Essentially a revision and enlargement of the second part of the author's "Introduction to Metallurgy", this volume surveys the entire field of extractive metallurgy. As a means of emphasizing the basic principles of the subject, the unit process method is used rather than a presentation of the subject on a metal-by-metal basis. In addition to the material normally covered in such a text,

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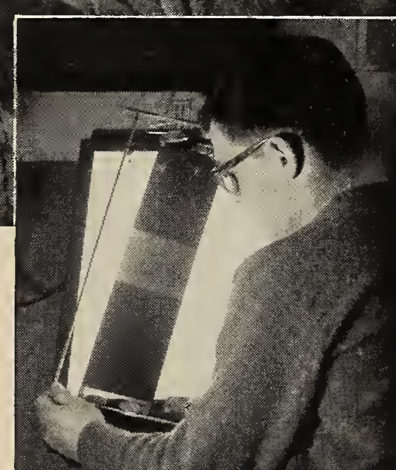

(Continued from page 142)

topics from physical metallurgy have been included, such as metal crystals, equilibrium diagrams, and Gibbs' phase rule. (Joseph Newton. New York, Wiley, 1959. 532 p., $9.75.)

*APPLIED SOLAR ENERGY RESEARCH, 2nd. ed.

The work of laboratories and of individuals engaged in solar energy research is described, and a bibliographical survey is made of the field. Arrangement of the bibliography is by broad subject divisions which include such aspects as solar radiation and its effects, and the use of solar energy as heat-low temperature conversion, as heat-high temperature conversion, and as light. (Phoenix, Association for Applied Solar Energy Research, 1959. 275 p., $7.50.)

METAL FATIGUE

A symposium of lectures presented at a week-long course at Nottingham University, designed to present to practising engineering designers the known facts about metal fatigue and its effects on design. Each chapter, or lecture, is by an expert in the field, and the volume is divided into three sections. The first of these deals with the fundamentals of fatigue, including the theory of fatigue failure, stress concentration factors, residual stesses, corrosion fatigue, temperature effect.

The second section is concerned with the fatigue properties of engineering materials and components, including high-temperature alloys, aluminum alloys, cast iron, brass, aircraft, joints and welds. The last section discusses the fatigue testing of engineering components, including bearings, welded structures, and aircraft structures, and the reproducibility of results in fatigue testing. References for further reading are included. (Ed. by J. A. Pope. Toronto, Ryerson, 1959. 381 p., $12.50.)

*EXAMPLES OF THE DESIGN OF REINFORCED CONCRETE BUILDINGS

In the first section of the book the author gives design calculations of bending-moment factors and structural parts, based on British Standard Codes and data for design. The second part deals with details in the design of a typical multiple-story building which has been planned to incorporate as many of the matters treated in the code as is practicable. New material includes revised bending-moment factors; the load-factor method applied to the design of structural parts subject to bending; concentrated loads on slabs spinning in one or two directions, and flat-slab floors as parts of a frame. (C. E. Reynolds, London, Concrete Publications, 1959. 265 p. $3.00.)

*RADIO STATIONS: INSTALLATION, DESIGN AND PRACTICE

A highly practical approach to the subject for the planning or station design engineer and the field installation technician. Based on up-to-date practice, each aspect is discussed, ranging from general planning, site selection, and ground systems to detailed station layouts, equipment rooms, message distribution systems and wiring systems. Although largely devoted to small station design, much of the material included is also applicable to large stations. (G. A. Chappel. New York, Pergamon, 1959. 248 p., $7.50.)

*NATURE AND PROPERTIES OF ENGINEERING MATERIALS

Here is information on basic materials for specific engineering applications. A consideration of the basic concepts of interatomic and intermolecular forces and their relationship to the structural characteristics of crystalline and amorphous materials forms the basis of the discussion of the phenomena of diffusion, crystallization, phase transformation and phase equilibria. Then follows a more specific development of the characteristic physical properties of metals and ceramics, electrical and magnetic properties of materials, corrosion, friction and lubrication, concrete, and protective coatings. (Z. D. Jastrzebski. New York, Wiley, 1959. 571 p., $11.00.)

*FOUNDATIONS OF AERODYNAMICS, 2nd. ed.

The fundamentals of perfect, compressible, and viscous flows is presented. In general, specific technical applications are not treated except as illustrations of the underlying principles. In this edition, the chapter on energy relations has been rewritten, and the treatment of one-dimensional compressible flows has now been expanded to include sections on heat addition. The material on wings in compressible flow is now presented from the viewpoint of lifting surface theory, while the material on viscous flow includes an expanded discussion of compressibility in both laminar and turbulent flow. (A. M. Kuethe and J. D. Schetzer. New York, Wiley, 1959. 446 p., $11.75.)

*MIDWESTERN CONFERENCE ON SOLID MECHANICS, PROCEEDINGS, 1959

Papers in this volume indicate the directions of analytical research and fundamental experiments in the field of solid mechanics. General areas covered include shell theory and shell deformation, buckling, thermal stresses, wave mechanics, vibration, and strain. The twenty-nine papers included range from basic topics such as the impact of cylinders of different areas and the collapse load of a spherical cap to specialized treatments of spin dynamics of a thrusting rocket in a vacuum and bending waves in free-free beams. (Austin, University of Texas, 1959. 530 p., $12.50.)

*MIDWESTERN CONFERENCE ON FLUID MECHANICS, PROCEEDINGS, 1959

Aerodynamics, heat transfer, characteristics of hypersonic and tangent flow, shock waves, boundary layer conditions, lubrication, and wave motions are the general areas covered by the thirty papers in this volume. Specifically, papers deal with such topics as secondary flow in straight open channels, theoretical and experimental study of heat transfer magnetic fields, an extended Reynolds analogy, and scale effects in turbulent shock wave boundary layer interactions. (Austin, University of Texas, 1959. 465 p., $12.50.)

*INTERNATIONAL SYMPOSIUM ON PLASTICS TESTING AND STANDARDIZATION

A collection of papers, divided into four sections, dealing with the achievement of national standards. The engineering properties of plastics, the thermal properties of plastics, and molecular characterization. (Philadelphia, American Society for Testing Materials, 1959. 276 p., $6.00 S.t.p. 247.)

(Continued on page 146)

The Use Of Air Offers Great Prospects For Increasing Industry's Productive Capacity

—Thomas Alva Edison

Today, when much is being written on the necessity of reducing overhead, it is significant that custom engineered air equipment is leading the way to increased plant efficiency and lower operating costs. For example, in delivering clean, dry air or gas continuously at constant pressure, Hoffman Multistage Centrifugal Blowers and Exhausters and Hoffman Positive Displacement Cycloblowers are at work handling a wide variety of products. These range from the crating of fragile eggs to the rugged service demands of Pneumatic Conveying.

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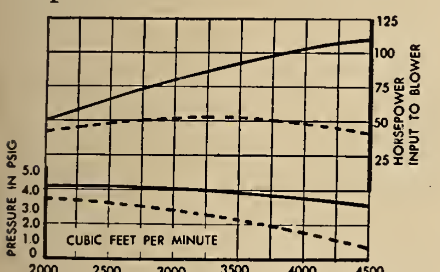
Hoffman Centrifugal Blowers and Exhausters furnish pressures up to ten pounds per square inch or vacuums up to 12 inches of mercury with volumes to 20,000 cfm. By varying the number of stages and utilizing different types of impellers, various ratings and operating characteristics can be obtained. Centrifugal Units are furnished with radial or backward curved impellers or combinations of these types to satisfy individual process requirements. The performance characteristics of these impellers are illustrated in Graph "A".



Graph A

The radial impeller has a relatively flat pressure characteristic throughout its volume range. A backward curved impeller differs from the radial impeller in that it falls off in pressure as volume increases. The graph shows that the horsepower requirement of the backward curved impeller reaches a maximum and then falls off to provide a non-overloading characteristic. Economy of operation is assured since power is consumed only in proportion to the actual air or gas volume handled. The absence of any internal wearing surfaces and the lubrication of bearings in outboard mounted housings makes it impossible to contaminate the air or gas handled.

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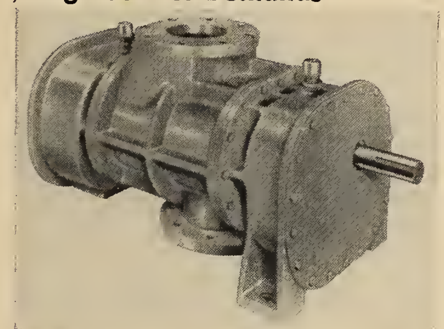
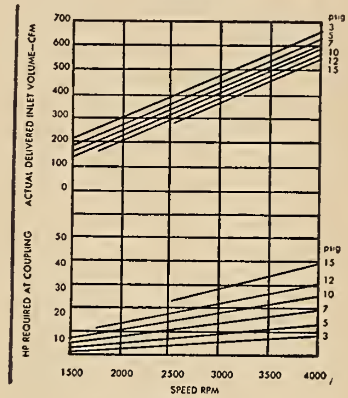
Cycloblower Meets Tough Service Demands



Designed for similar tough service demands, the Hoffman Cycloblower is a compact axial flow, Positive Displacement Blower/Exhauster incorporating perfectly symmetrical rotor forms. Interruption of the continuity of rotor seals without sacrifice of the advantages of such forms allows increased water rates for wet compression and vacuum service. Shock, temperature and loading due to build up of pressure is effectively eliminated. The Cycloblower has a normal operating range up to 15 lbs. per square inch and 15 inches of mercury with dry compression. With water injection, vacuums of 22 inches of mercury and pressures of 30 lbs. per square inch can be obtained. Volume capacities range from 80 cfm to 3500 cfm.

A Positive Displacement Unit is a constant volume machine, whereas a Centrifugal is a variable volume machine. In Graph "B" it will be noted that at a constant RPM, the Positive Displacement Blower/Exhauster can deliver pressures from 3 to 15 lbs. If a unit is selected to operate at 500 cfm and 3 psig, it will have to operate at approximately 3050 RPM and require 8 HP. Should changes in the process



Graph B

require more pressure, the Positive Displacement Unit will automatically build up to the required pressure while still maintaining constant volume. It will, of course, require the additional horsepower as indicated in the graph. A pre-set relief valve acts as a built-in safety device. It limits the amount of pressure which can be built up when the requirements of the system exceed the capabilities of the equipment. Lubrication within the compression chamber is unnecessary since the rotors do not touch. The possibility of oil contamination is thus avoided in the same manner as it is in the Hoffman Centrifugal Units.

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Wide Performance Range

Centrifugal and Positive Displacement Units have an overlapping range of performances. Without cost or obligation Hoffman engineers will recommend the most efficient units for your particular requirement. Whatever your problem, feel free to call on Hoffman's quarter of a century of engineering experience and background to meet your special needs. Send now for these free helpful booklets.

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☐ CB-157 — How Cycloblowers can help increase production.

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• LIBRARY NOTES

(Continued from page 144)

*A.S.T.M. MANUAL FOR RATING DIESEL FUELS BY THE CETANE METHOD

This manual has the two-fold purpose of revising and bringing up to date the ASTM Cetane Method D613, and of serving users of ASTM ignition quality rating engines by providing detailed information and data on the operation and maintenance of the rating equipment. (Philadelphia. American Society for Testing Materials, 1959. 132 p., $8.50.)

TECHNICAL BULLETINS

Airports

Airports for jets, by J. E. Peterson. Chic., American Society of Planning Officials, 1959. $2.50.

Amplifiers

Low-frequency amplifier systems, ed. by A. Schure. N.Y., Rider, 1959. $1.80. R-F amplifiers, ed. by A. Schure. N.Y., Rider, 1959. $2.40.

Annual reports

Annual report of the Board of Regents of the Smithsonian Institution for the year ended June 30, 1958. Wash., U.S. Gov't Printing Off., 1959. $3.75.

CABMA Register

CABMA register of British industrial products for Canada, 1959-1960. London, Iliffe, 1959.

Canada. Dept. of Mines and Technical Surveys

Markets for iron and steel products in western Canada, by T. H. Janes. 1959. 25c. (Mineral Resources Division Bulletin MR33) A survey of the uranium industry in Canada, by J. W. Griffith. 1959. 50c. (Mineral Resources Division Bulletin MR 34.) A survey of the petroleum industry in Canada, 1957 and 1958, by R. A. Simpson and R. L. Borden. 1959. 50c. (Mineral Resources Division Bulletin MR 35.)
Flotation of uranium ores from the Elliot Lake area, Ontario, by W. R. Honeywell. 1959. 25c. (Mines Branch Technical Bulletin TB 2.)
Heavy media separation in aggregate beneficiation, by V. A. Haw. 1959. 25c. (Mines Branch Technical Bulletin TB 5.)
Relationship of various factors to the quality of coked briquets made from mixtures of coking coals and inert material, by E. Swartzman. 1959. 25c (Mines Branch Technical Bulletin TB 6.)
Helicopter operations of the Geological Survey of Canada, by Officers of the Geological Survey of Canada. 1959. 75c. (Geological Survey of Canada Bulletin 54.)

Canada. National Research Council

Flight tests of an experimental helicopter rotor blade electrical de-icer, by J. R. Stallabrass. 1959. (Aeronautical report LR 263.)
A probability analysis of coincident gust and manoeuvre loads in low-flying aircraft, by S. D. Baxter and others. 1959. (Aeronautical report LR 264.)
Comparison of some experimental and theoretical data on damping-in-roll of a delta-wing body configuration at supersonic speeds, by L. T. Conlin and K. J. Orlik-Ruckermann. 1959. (Aeronautical report LR 266.) Half-model measurements of longitudinal force and moment characteristics of AGARD model "B" at subsonic and supersonic speeds, by J. G. Laberge. 1959. (Aeronautical report LR 267.)
The corrosion behaviour of the major architectural and structural metals in Canadian atmospheres; summary of two year results. Ottawa, Associate Committee on Corrosion Research and Prevention, 1959.
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Combined analog-digital simulation of engineering problems, by F. W. Pruden. 1959. (Mechanical engineering report MK 6.) Requirements for a hybrid analog-digital computer, by D. C. Baxter and J. H. Milsum. 1959. (Mechanical engineering report MK 7.) Recent failures point out importance of snow loads on roofs, by H. J. Thornton and W. R. Schriever. (Reprinted from National Builder, vol. 8, no. 5, May 1959, p. 18.) 10c. What frost action did to a cold storage plant, by J. J. Hamilton and others. (Reprinted from the ASHRAE Journal, vol. 1, no. 4, April 1959, p. 54-58.) 10c.
Insulation in northern building, by R. E. Platts. 1959. (Div. of Bldg. Res. Technical paper no. 75.) 25c.
The compacted snow road. 11. Climatic considerations, by B. H:son Ager and tr. by D. A. Sinclair. 1959. (Technical translation 816.)
Snow as road-building material, by K. Putkisto and tr. by E. Perem. 1959. (Technical translation 822.)

Electron tubes

Phototubes, ed. by A. Schure. N.Y., Rider, 1959. $1.80.

Highway engineering

Concrete pavement: subbase and joint construction. Wash., Highway Research Bd., 1959. (Bulletin 229.) $1.00.
Highways and economic development. Wash., Highway Research Bd., 1959. (Bulletin 227.) $1.60.
Highway pavement design in frost areas, a symposium: part 1: Basic considerations. Wash., Highway Research Bd., 1959. (Bulletin 225.) $2.60.

Isotopes. Radioactive

Use of radioactive isotopes for measurement of cutting tool wear, by G. Engstrand. Stockholm, Royal Institute of Technology, 1959. (Transactions 143.)

Mathematics

Algebraic theories, by L. E. Dickson. N.Y., Dover, 1926. $1.85. (Reprint).
An elementary treatise on Fourier's series and spherical, cylindrical, and ellipsoidal harmonics, with applications to problems in mathematical physics, by W. E. Byerly. N.Y., Dover, 1893. $1.95. (Reprint).
The theory of numbers and diophantine analysis, by R. D. Carmichael. N.Y., Dover, 1914. $1.50. (Reprint).
A treatise on algebraic plane curves, by J. L. Coolidge. N.Y., Dover, 1959. $2.70. (Reprint).

Photogrammetry

Photogrammetry: developments and applications, 1959. Wash., Highway Research Bd., 1959. (Bulletin 228.) $1.20.

Tobermorite

The surface energy of tobermorite, by S. Brunauer, D. L. Kantro and C. H. Weise. Skokie, Ill., Portland Cement Association, Research and Development Labs., 1959. (Bulletin 105.)

Wage payment plans

A guide to systematic wage and salary administration, by R. D. Gray. Pasadena, Calif., Calif. Institute of Technology, Industrial Relations Section, 1959. (Bulletin 29.) $1.00.

Water analysis. Copper.

Copper in domestic water systems (a review), by J. Ungar. Ottawa, Dept. of Mines and Technical Surveys, Mines Branch, 1959. (Information circular 107.) 25c.

Water supply. Cold climates.

Water supply and sewage disposal in permafrost areas of Northern Canada, by H. B. Dickens. (The polar record, vol. 9, no. 62, May 1959, p. 421-32.)

Education

Education of the academically talented; summary of a discussion by the Trustees of the Carnegie Foundation for the Advancement of Teaching. (Reprinted from the 1958-1959 annual report.)
A survey of the practical training for students at the German technical universities, comp. by H. Winter and H. Hirrich. Brunswick, Germany, Technical University, 1958.

Electrical engineering

Basic electronics, by Van Valkenburgh, Nooger & Neville, Inc. vol. 6. N.Y., Rider, 1959. 136 p. $2.90.
Master receiving-picture tube substitution guide book, by H. A. Middleton. N.Y., Rider, 1959. $7.45.
Principles of transistor circuits; introduction to the design of amplifiers, receivers and other circuits, by S. W. Amos. N.Y., Rider, 1959. $3.90.
R-L-C components handbook, by D. Mark. N.Y., Rider, 1959. $3.50.
Repartition du potentiel et du courant dans les electrolytes, by R. H. Rousselot. Paris, Dunod, 1959. 980 Fr.

Engineering universities. U.S.A.

Engineering college research review, 1959, ed. by R. Contini and P. T. Bryant. 9th ed. Urbana, Ill., Engineering College Research Council of the American Society for Engineering Education, 1959. $2.00.

(Continued on page 171)

buildings. Applicant must have at least 8 years' experience in these fields and be able to take complete responsibility. Administrative and personal qualities will be considered as well as professional. Excellent salary to start, plus eligibility for profit sharing. Please apply with full particulars to: Izumi Arnott and Sugiyama, Architects and Engineers, 2151 Albert Street, Regina, Saskatchewan. File No. 6959-V.

MECHANICAL ENGINEER required for engineering department of an expanding Maritime Province pulp and paper mill. Applicant should have 2 to 5 years' engineering experience. State age and complete history of experience and education. Reply to File No. 6963-V.

MECHANICAL ENGINEER. Challenging opening for a Mechanical Engineer at a large experimental establishment near Quebec City concerned in part with rocket testing for upper atmosphere investigations. Some past experience in dealing with high pressure fluid or gas systems is desirable. The work involves the experimental ground firing of rocket components together with the design, modification, and calibration of relevant test equipment. The mechanical project engineer will be responsible for test programmes and for a team of test technicians, etc. Ingenuity, imagination and drive are required as nearly all the work is of a novel character and none is routine. File No. 6967-V.

MECHANICAL ENGINEER. Required by a heavy industry in the Eastern Townships, with four to six years' experience in machine design, plant and building lay-out, also a recent graduate Mechanical Engineer for maintenance engineering. Permanent positions with good starting salary. Wide range of employee benefits. Excellent recreational and educational facilities in a modern community. File No. 6968-V.

MISCELLANEOUS

ENGINEERS FOR SALES, project, design, research, development, control and management. Graduates of all types and ages required by clients of The Technical Service Council, a non-profit industry, sponsored placement service. Write 2 Homewood Avenue, Toronto 5, Ontario, for an application. There is no charge for work done on your behalf. File No. 6648-V.

TECHNICAL SALES & SERVICE ENGINEER. Recent graduate to manage sales territory. Montreal area marketing petroleum products to industry. File No. 6914-V.

SALES ENGINEER — Excellent opportunity for aggressive graduate, Mechanical or Chemical engineer, 25-35 years of age who is interested in selling engineered equipment to Pulp & Paper Industry. Some experience in Pulp & Paper Industry desirable. Reply in confidence to File No. 6921-V.

SALES ENGINEERS, two recent graduates, Mechanical or Electrical required by progressive manufacturer of ventilating, air conditioning and related engineered products. Some experience preferred, but not essential. Following completion of company training course successful candidates will be assigned to Hamilton and Montreal Branch Sales Offices. Wide range of employee benefits and attractive starting salary. Send complete resume and salary requirements. File No. 6923-V.

UNUSUAL OPPORTUNITIES. Continued growth of nationally known Toronto manufacturer of consumer products has created some very attractive openings for alert, aggressive personnel interested in advancement based on initiative and performance. PRODUCT ENGINEERS. To develop, design, test and specify new products and improvements to existing lines. PROCESS ENGINEERS. To plan and provide efficient mass production processes and equipment. INDUSTRIAL ENGINEERS. To establish methods, time standards, plant layouts, material handling, systems etc. Engineers with 5 years of applicable experience should apply in strict confidence, supplying complete resume of education, experience, present earnings and a recent photograph. File No. 6945-V.

FIRE PROTECTION ENGINEER. Montreal office of well known Canadian firm of Insurance Brokers servicing large industrial clientele requires engineer experienced in fire inspection work and familiar with underwriters' fire protection standards. Good opportunity for the right man. Salary according to experience and ability. Pension plan and insurance benefits. Please apply, giving full particulars, to File No. 6957-V.

ENGINEERING PARTNER. Engineer establishing practice in Northern Ontario desires engineering partner or association with consultant. Financial investment required. File No. 6960-V.

APPLICATIONS for several faculty appointments for July 1, 1960 are now being considered. Applicants with teaching experience in Civil, Electrical and Mechanical Engineering courses at the senior level should write to The Director, School of Engineering, Carleton University, Ottawa, Ontario. File No. 6961-V.

UNIVERSITY OF ALBERTA Invites applications for Academic Appointments in the Faculty of Engineering. **Chemical Engineering.** Assistant Professor — Ph.D. preferably with background in Fluid Mechanics and Reaction Kinetics. **Civil Engineering.** Two Assistant Professors — Ph.D. or M.Sc. with background in Structural Analysis and Design. Assistant Professor — Ph.D. or M.Sc. with background in Strength of Materials and Structural Analysis. Assistant Professor — Ph.D. or M.Sc. with background in Sanitary Engineering. **Electrical Engineering.** Professor — Ph.D. with substantial experience in Teaching and/or Research and with special background in Microwaves or Transistor Circuitry. Appointment to be made June 1, 1960. Assistant Professor — Ph.D. or M.Sc. with background in electronics preferably in Transistor Circuitry or Microwaves. **Mechanical Engineering.** Assistant Professor — Ph.D. or M.Sc. with background in Thermodynamics. Assistant Professor — Ph.D. or M.Sc. with special background in Fluid Mechanics and Heat Transfer. **Petroleum Engineering.** Assistant Professor — Ph.D. or M.Sc. preferably with background and interest in Drilling Methods and Reservoir Engineering. Applications will be considered only from persons having first class academic records and with proven ability, or strong recommendations as to their potential, in Teaching and Research. Some industrial experience is desirable but not essential. Appointees will be expected to participate in both undergraduate and graduate teaching and to initiate and direct graduate research programs. Considerable freedom to engage in consulting work may be expected. Promotion prospects for the right people are excellent. The salary schedule for the 1960-61 academic year is: Assistant Professor — $6,000 to $8,200; Associate Professor — $8,500 to $10,700; Professor — $11,000 minimum. Except where otherwise noted appointments will commence September 1, 1960. Fully documented applications including recent photograph; personal statistics; transcripts of all academic records; resume of teaching, research, and industrial experience; list and reprints of publications, and list of references may be sent to. **Dean, Faculty of Engineering, University of Alberta, Edmonton, Alberta. File No. 6956-V.**

PERSONALS

(Continued from page 118)

Robert T. Bailey, M.E.I.C. (Queen's '48) has become the city engineer of Windsor, Ont.

John G. Frost, M.E.I.C., a partner in the firm of Wiggs, Walford, Frost and Lindsay, consulting engineers, Montreal, was recently elected to the council of the American Institute of Consulting Engineers.

N. S. Trouth, M.E.I.C. (Alberta '49), manager of the Kelwood Corporation, was recently re-elected president of the Urban Development Institute of Alberta. V. S. G. Lewis, M.E.I.C., general manager of land development, Engineered Buildings Limited, is the new vice-president.

Glynne J. Evans, JR.E.I.C. (Alberta '50), formerly of the Texaco Exploration Company, Edmonton, has been elected vice-president and general manager of the Montreal-Hamilton product pipe line of the Trans-Northern Pipe Line Company.

William N. Isberg, JR.E.I.C. (Queen's '55) has been appointed sales engineer for special projects at Bristol Aero-Industries, Winnipeg Division.

W. N. Isberg
JR.E.I.C.

R. C. T. Stewart, M.E.I.C. (McGill '49) has been appointed executive vice-president of Cameron Contracting Limited.

D. K. Teasdale, M.E.I.C. (Nova Scotia Technical '49) has been appointed senior civil and hydraulic engineer of the Nova Scotia Light and Power Company and subsidiary companies.

E. R. Skanes, JR.E.I.C. (Nova Scotia Technical '51) has accepted a position with the Department of Public Works of Newfoundland in St. John's. He was formerly with Bowaters Nfld. Pulp & Paper Mills, Corner Brook.

G. Douglas Zimmerman, M.E.I.C. (Toronto '52) has been elected executive vice-president and director of Canadian Curtiss-Wright Ltd., Montreal. He has also been named managing director of the Canadian operation.

Howard S. Rothman, JR.E.I.C. (McGill '58) has been appointed a director of the Secant Construction Company Montreal.

Business and Industrial Briefs

Appointments and Transfers

KENNETH C. BRUMLEY has been appointed Advertising and Publicity Supervisor of the Plywood Manufacturers Association of British Columbia. The announcement was made in December by Colin J. Hempsall, Advertising and Publicity Manager for PMABC. Mr. Brumley returned recently to the west coast after serving for two years with the public relations division of the Aluminium Limited group of companies.

E.C.C. Canada Limited announce the appointment of **MR. V. SOUTHON**, Assoc. I.E.E., to the position of Chief Inside Sales Engineer and Office Manager of their Toronto Office. Mr. Southon was recently Secretary-Treasurer of Electrical Maintenance and Repairs Co. and was formerly with the Hydro-Electric Power Commission of Ontario and Senior Assistant Commercial Officer with the Eastern Electricity Board in England.

Three key appointments in the management of the Aeronautical Group are announced by A. V. Roe Canada Limited. They are: **KENNETH W. BROWN**, as Vice-President and General Manager of Avro Aircraft Limited; **JOHN L. PLANT**, as Vice-President and General Manager of Canadian Applied Research Limited; and **BURTON A. AVERY** as Vice-President and Assistant General Manager, Orenda Engines Limited. **HARVEY R. SMITH** remains Chairman and President of the three Companies, all of which are located in the Toronto area.

Canadian Westinghouse executive **EDWARD R. NARY** who has been director of the company's headquarters manufacturing department since 1956, retired in December after 45 years service with the Westinghouse organization in Canada, the United States and Europe.

The Lamp Department of Canadian General Electric Company Limited announces the appointment of **KEITH S. WOOD** as Manager — Eastern Sales Region. He has his headquarters in the Company's office at 280 Faillon St. W., Montreal.

Business News

QUICK-MAKE, QUICK-BREAK load interruption is offered by a new switch announced by Canadian Westinghouse. The switch designated "Type LCB" is essentially a design improvement over the previous "LCB" switch and is CSA approved. The device will close without hazard to the operator against a 40,000 ampere fault.

DESILICIZER is a new process now commercially available. Introduced by the Cochrane Corporation, Philadelphia 32, Pa., it reduces Silica and eliminates HCO_3 and CO_3 alkalinity in boiler feedwater. It is claimed to be particularly suitable for medium pressure boilers (450 to 1100 psig) and can be added to existing Zeolite Softener Systems.

THE WORLD'S FIRST airborne gravity gradiometer, a Canadian development, has been unveiled to leading scientists from all over the world. Dr. Hans Lundberg has demonstrated the device to the first international symposium of Arctic geology sponsored by the Alberta Association of Petroleum Geologists. Scientists say the gradiometer will be extremely valuable in the Canadian Arctic. By providing fundamental gravity data revealing geological structure, it will aid in the search for essential oil, gas and minerals. It is also expected to help in determining the true shape of this planet as an aid in navigating nuclear submarines, ICB's, rockets and space ships.

TRANSISTORIZED POCKET RECEIVERS of a new type can now be had for use with the Multitone "Personal Call" Staff Location System. Known as the Series Eight, the receivers are for use in low to medium ambient noise levels and are capable of receiving a spoken message as well as a selective call signal. Improvements include greatly increased impact resistance of the case and increased sensitivity. Weight, complete with mercury batteries, is only 5¾ ounces.

AIR CONDITIONING BY NATURAL GAS is foreshadowed in arrangements recently announced by Robertshaw-Fulton Controls (Canada) Limited. A machine of a new type, called a Free Piston Refrigerant Compressor, will be manufactured and marketed by Robertshaw-Fulton under exclusive license. The piston is called free because there are no mechanical links from it to the use of power. Combustion of gas takes place at one end of the cylinder, and compression of the refrigerant such as freon at the other. From this point cooling action is the same as in the conventional air conditioning unit.

A LIQUID LOCK for metal parts, to prevent costly breakdowns due to loose nuts and bolts, is offered by Loctite Sealant, a product of American Sealants Company, Hartford, Conn. Loctite is a thin liquid plastic that hardens between closely fitting metal parts, forming a tough bond that resists heat and oil.

A CANADIAN AUTOMATIC DATA LOGGER has been ordered by Quebec Hydro for its Charland Substation. Either fully automatic (at stated intervals) or manually started logging is possible with the logger, which prints data on a paper roll together with a code number to indicate the point logged and a time reading in hours, minutes, seconds and thousandths of a second from a 24 hour digital clock. Central Dynamics Ltd., whose manufacturing facility is at Pointe Claire, Quebec, is the first Canadian company to design and completely manufacture this type of equipment in Canada.

(More Briefs on page 162)

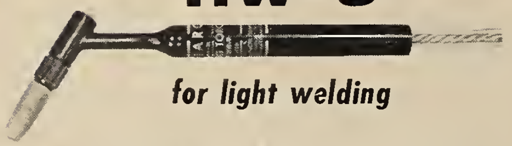
WELDING IS EASIER WITH

HELIARC

TRADE MARK

TORCHES

HW-9



for light welding

Air-cooled — 75 amp. A.C. — D.C.
Electrode sizes: .020 to 1/16 in.

for light welding

Air-cooled — 130 amp. A.C. — D.C.
Electrode sizes: .020 to 3/32 in.

HW-17

for medium welding

Water-cooled —300 amp. A.C — D.C.
Electrode sizes: .020 to ⅛ in.

HW-18

for heavy-duty welding

Water-cooled — 500 amp. A.C. — D.C.
Electrode sizes: .040 to ¼ in.

HW-12

HW-8

for spot welding

Water-cooled — 250 amp. A.C. — D.C.
Electrode sizes: 1/16 in to 5/32 in.

for mechanized welding

Water-cooled — 500 amp.
A.C. — D.C.
Electrode sizes:
.040 to ¼ in.

HW-13

WELD ALL THESE METALS WITHOUT FLUX

Aluminum • Hastelloy alloys • Multimet alloys • Inconel • Silicon-copper alloys • Silver and silver-cladding • Magnesium Alloys
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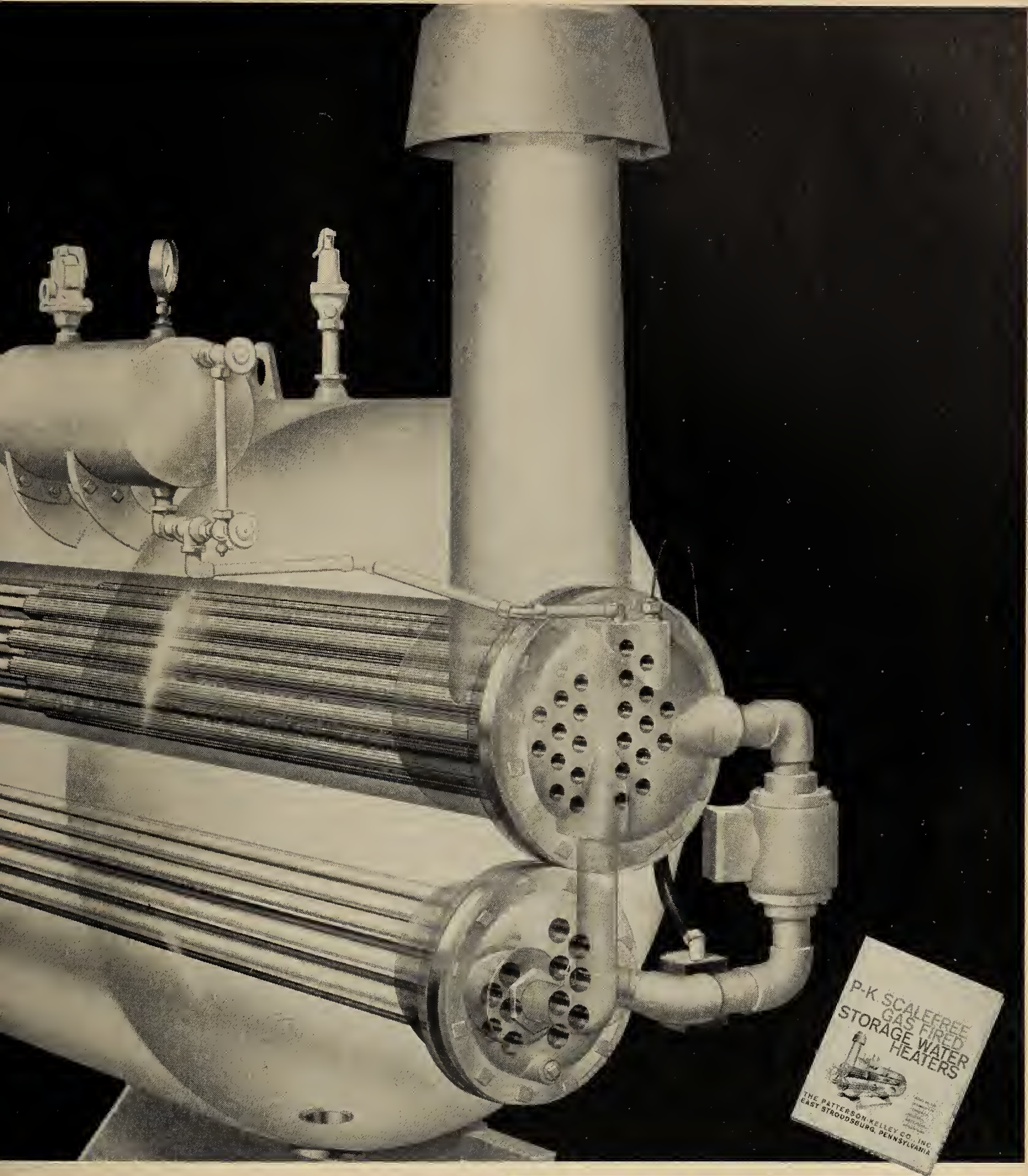

No foundation is necessary. A rugged skid-in type base is supplied. It is easily accessible for inspection. Tube bundles are removable.

SCALEFREE 230 is completely safe. It has a fail-safe chain of built-in protective devices. It is available in more than 100 storage and recovery combinations. Storage capacities range from 250 to 4000 gallons. Recovery sections range from 390,000 to 2,215,000 Btu. Send the coupon for complete information.

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☐ Please have a P-K Sales Engineer call to discuss design and operational features.

Name________ Position________
Company________
Address________
City________ Zone____ State________

• BRIEFS

(Continued from page 154)

THROUGH MILES OF TUNNELS, with installation and upkeep costs far lower than for less efficient methods of ventilation, "Fabron" P.V.C. Brattice Cloth provides air proof protection for the miner. England's National Coal Board approved the use of "Fabron" in their mines, but it is suitable for all types of underground mining. "Fabron" does not support combustion and is self extinguishing. Because of its colour, carbon black imparts maximum ageing properties to the material.

THE COMPLETE LINE of Link-Belt car spotters, car pullers and 33 accessories is described in a new 20 page book "Haulage Machines". The book, number 2892, also provides engineering and selection data.

MANGJET, A NEW ELECTRODE, is announced by the Lincoln Electric Company of Canada Limited, Leaside, Ontario. Intended for easier and cheaper welding of 12-14% manganese steels, the new electrode is suitable for building up manganese steel hard surfacing deposits on either manganese or carbon steels, and also for making sound joints between two manganese steel parts or between manganese and carbon steel parts. Mangjet is a low hydrogen, iron powder electrode with high deposit rates, smooth beads and a steady arc. It is used with both AC and DC welding machines.

FASTER, MORE FLEXIBLE application in measuring gases, vapours and liquids in industrial process streams and atmospheres is permitted by a completely new and portable infra-red analyzer that Mine Safety Appliances Company has developed. The MSA Model 300 LIRA analyzer weighs only 30 pounds and is housed in a case measuring only 8 inches in height and width, and 19 inches in length. Compactness and light weight permit rapid transfer and facilitate use of the analyzer where moderately priced instrumentation is required.

COSTLY PIPING alterations at compressor stations along natural gas pipe lines is reduced by a unique electronic machine which the Worthington Corporation has developed. This machine allows Worthington engineers to create electrical circuit analogies which accurately predict machine and system performance before design and construction are finalized. They can anticipate vibration patterns that cut efficiency and cause maintenance problems. At the compressor stations multiple compressors repressurize natural gas being piped to market areas and discharge it back into the main line pipe. Pulsations cause the vibration and wear.

HORIZONTAL CONTROL for location of highways, pipelines, transmission lines and other construction projects is the purpose of the Tellurometer system of distance measurement. A completely redesigned model of the original system is now announced by Highway Information Services of Washington, D.C. The new "micro-distancer" permits interchangeability of units—either unit may be used as the master or the remote, permitting readings to be taken from either end of a line. Equipment is produced by Tellurometer Inc. of Washington.

HUMAN JUDGMENT VARIABLES are eliminated and the operator can start or stop the Clark packaged compressor engine, by means of automatic control panels recently introduced, consisting of a complete pneumatic starting and stopping system which operates at 75 psi air or gas pressure. The control is furnished as an integral part of the compressor package.

DRILLING SMALL HOLES in stone, concrete, brick and other building materials is the job of the Wasp, a new plug hole drill announced by Atlas Copco. With an aluminum handle, casing and front head, the unit weighs only 6.6 lbs. and is claimed to be the lightest air-operated, self-rotating plug hole drill on the market.

AS AN IMPELLER "Delrin" does not absorb moisture and is lighter in weight than metals but stronger than most other plastics. As a motor component it is in use in a power saw as a carburetor insulator to prevent vapour locks. In both cases the new moulded plastic part eliminates other costs, such as machining required for metal parts. This acetal resin was developed after 10 years' research and an expenditure of $42,000,000, says Du Pont.

CENTRALIZED TRAFFIC CONTROL is going into operation on the C.N.R. mainline between Hawthorne, Ont, and Coteau, Que., a distance of some 70 miles. This will place all trains between Montreal and Ottawa under automatic signalling. C.T.C. is a modern signalling system by which the operation of traffic can be governed by a despatcher seated in front of a panel. It replaces the working timetable and eliminates the transmission of train orders between despatcher and train crews. In addition, the new system will allow train movements to be constantly monitored.

THROWING AND STORING grain, sand or other granular small lump bulk materials to heights of 20 feet over a radius of 50 feet is possible with the wheel mount Swivel-Piler developed by Stephens-Adamson of Aurora, Ill. Easily moved and operated by one man, the Stephens-Adamson swivel-piler is designed for ground storage of bulk materials, and is especially suited to piling, original filling, turning or aerating grain in storage buildings.

ENGINEERING DRAWINGS can be "retrievably miniaturized" by means of the new Revolute continuous reducing printer and processor announced by the Paragon-Revolute Division of Charles Bruning Company. Retrievable miniaturization combines advantages of miniaturization with visual communication of reliable information. Invariably a print cannot be a reliable copy unless it clearly reproduces all information from the original drawing. The new process reduces drawings to a size which will be sufficiently readable in the ultimate copy prints. It is a fast, economical method of reducing the cost of making, handling and storing prints without disposing of existing facilities or making drastic changes in current drafting standards or print-making systems.

ENGINEERING PRODUCTS represented 41.9% of the U.K.'s total manufacturing output in 1958, according to the U.K. Information Services. This compares with 29.2% in 1935.

• LIBRARY NOTES

(Continued from page 146)

Mathematics
Mathematiques generales, by M. Denis-Papin. 7th ed. vol. 1. Paris, Dunod, 1959. 580 Fr.

Matrices
Elements de calcul matriciel, by G. Cahen. 2d ed. Paris, Dunod, 1959. 750 Fr.

Metals. Statistics
Statistical tables on aluminum, lead, copper, zinc, tin, cadmium, magnesium, nickel, mercury and silver. 46th annual issue, 1949-1958. Frankfurt, Metallgesellschaft Aktiengesellschaft, 1959.

Metrology
Metrologie appliquee (methodes et instruments de mesures), by M. Denis-Papin and others. 3rd ed. Paris, Dunod, 1959. 580 Fr.

Nuclear energy
Effects of nuclear radiation on men and materials, by T. C. Helvey. N.Y., Rider, 1959. $1.80.
Liberation et utilisation de l'energie nucleaire, by L. Jauneau. Paris, La Documentation Technique du Batiment et des Travaux Publics, 1959. 535 Fr. Peaceful uses of nuclear explosions; a literature search, comp. by H. E. Voress. Wash., U.S. Atomic Energy Commission, 1959. (Technical Information Service 3522.)

Pipe joints
Design of welded pipe fittings, by P.H.R. Lane and R. T. Rose. London, British Welding Research Assn., 1959. 15/-.

Probabilities
Probabilite et information, by A. M. Yaglom and I. M. Yaglom and tr. by W. Mercouroff. Paris, Dunod, 1959. 1350 Fr.

Public works
Travaux publics, by C. Mondin. vol. 1. Paris, Dunod, 1959. 680 Fr.

Radio communication
Shortwave propagation, by S. Leinwoll. N.Y., Rider, 1959. $3.90.

Roads and streets
Highway finance, 1959 — a comparative report of road and street budgets. Ottawa, Canadian Good Roads Assn., 1959. (Technical publication no. 10) 25c.
Proceedings of the thirty-eighth annual meeting, Jan. 5-9, 1959. Wash., Highway Research Board, 1959.
Proceedings of the 12th annual meeting of the Institute of Traffic Engineers combined with Northwest Traffic Engineering Conference. Seattle, 1959.

St. Lawrence River
The region with a future; the Gulf and Lower St. Lawrence, by H. Massue. Montreal, The Lower St. Lawrence and Gulf Development Assn., 1959.

Slide rules
La regle a calcul, by R. Dudin. 3rd ed. Paris, Dunod, 1959. 450 Fr.

Soil-cement
Cost estimate form for soil-cement construction. Chicago, Portland Cement Assn., 1959.

Steel, Structural
The plastic properties of rolled sections. London, British Welding Research Association, 1959. 8s6d.

REPRINTS ISSUED BY DOVER PUBLICATIONS, NEW YORK

A course in mathematical analysis, by E. Goursat and tr. by E. R. Hedrick and O. Dunkel. 3 vols. vol. 1: Applications to geometry, expansion in series, definite integrals, derivatives and differentials. 1959. 540p. $2.25. vol. 2, part 1: Functions of a complex variable. 1959. 259 p. $1.65. vol. 2, part 2: Differential equations. 1959. 300p. $1.65.
De magnete, by W. Gilbert and tr. by P. F. Mottelay. 1958. 368p. $2.00.
From magic to science; essays on the scientific twilight, by C. Singer. 1958. 248p. $2.00.
Functions of a complex variable, by J. Pierpont. 1959. 583p. $2.45.
A source book in mathematics, by D. E. Smith. 2 vols. 1959. $1.85 ea.
The theory of functions of real variables, by J. Pierpont. 2 vols. 1959. $2.45 ea.

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race St., Phila. 3, Pa.

Coal and coke, 1959. $3.00.
Coated and uncoated iron and steel sheet and strip, 1959. $3.00.
Electrical insulating materials (with related information), 1959. $8.75.
Metal powders and metal powder products (with related information), 1959. $2.25.
Petroleum products and lubricants (with related information), 1959. $9.00.
Textile materials (with related information), 1959. $8.50.

ASTA standards. The Association of Short-Circuit Testing Authorities, 36 Kingsway, London W.C. 2, Eng.

ASTA No. 22: 1959 — Rules for the short-circuit testing of circuit-breakers and automatic switches in combination with electric fuses and fuse-links. 10/-.

CSA standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

C22.1-1958, Suppl. R-1959: 50c.
0 122-1959: Specification for glued-laminated softwood structural timber. 2d. ed. 1959. $1.00.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

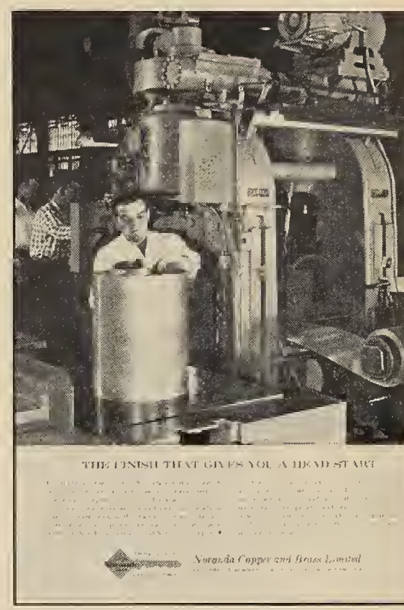
A one page, 4 colour insert placed by Noranda Copper & Brass Ltd., was judged the "best", by a fifty reader jury, in the December 1959 issue, from the viewpoints of ACCURACY—INFORMATION—and ATTRACTION.

The advertisement appeared on page 33. It is headed: "THE FINISH THAT GIVES YOU A HEAD START". The illustration shows an employee handling a coil of brass strip just off the production line. The copy emphasizes that brass strip produced by Noranda Copper & Brass Ltd. is ready for use by a manufacturer as it comes off the line. It continues by emphasizing the scientific control which is carried on through all the mining and manufacturing operations of the company.

This is the second time Noranda Copper & Brass Ltd. have won the Certificate during a 12-month period. The company's insert in the September issue was their previous "winner".

Advertising Manager of the company is Mr. R. C. DeVilliers.

Each month fifty readers are asked to evaluate the advertisements from the viewpoints of ACCURACY—INFORMATION and ATTRACTION and this opportunity is taken to thank all those who have assisted by their co-operative effort.



NORANDA COPPER & BRASS LTD. WINNING INSERT

The above illustration shows, on a reduced scale, the 4-colour insert which was judged the "best" from the viewpoints of ACCURACY—INFORMATION and ATTRACTION in the December 1959 issue. The advertisement appeared on page 33.

Index to Advertisers

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed below are the names of the Companies and Individuals whose advertisements appear in this issue.

MARCH, 1960

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Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

THE ENGINEERING JOURNAL
PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA VOLUME 43 NUMBER 4 APRIL 1960

MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

(35,170 copies of this issue printed)

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Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, Post Office Department, Ottawa.

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M-60-4

SUPPLIERS OF TOP QUALITY VALVES TO CANADIAN INDUSTRY FOR 126 YEARS

Meet the Authors

F. W. Buckley, M.E.I.C., B.Sc., Elec. (N.S.T.C. '38), chief engineer, Bathurst Power and Paper Company, Ltd., Bathurst, N.B. *(Bathurst's New 1250 p.s.i.g. Kraft Chemical Recovery Boiler and Back Pressure Turbine).*

After graduation Mr. Buckley joined the Nova Scotia Power Commission as a field engineer and later became design engineer on steam and hydro plant design. He has been associated with the Bathurst Power and Paper Company for the past 13 years. Mr. Buckley is a registered professional engineer in the Province of New Brunswick.

J. W. MacLaren, M.E.I.C., B.A.Sc., (Tor. '46), M.A. (M.I.T. '47), principal, James F. MacLaren Associates, Consulting Engineers, Toronto, Ontario. *(Supervisory and Automatic Control System for Winnipeg Unattended Pumping Station).*

Mr. MacLaren was with the firm of Gore and Storrie for three years as a junior project engineer on municipal and sanitary engineering works. He then joined his present firm, specializing in sanitary engineering.

D. J. Moon, M.E.I.C., A. Mem. A.I.E.E., senior electrical engineer, James F. MacLaren Associates, Consulting Engineers, Toronto, Ont. *(Supervisory and Automatic Control System for Winnipeg Unattended Pumping Station).*

Mr. Moon graduated in Electrical Engineering from the University of London, England, in 1950. After settling in Canada in 1945, he worked for the Department of National Defence and the Department of Transport where he was electrical engineer on the Welland Ship Canal. With his present firm he specializes in the electrical control requirements associated with sanitary engineering.

W. D. Hurst, M.E.I.C., B.Sc. (Manitoba '30), C. E. (Virginia Polytechnic Inst. '31), city engineer and chairman of commissioners, Greater Winnipeg Water District, Winnipeg, Man. *(Supervisory and Automatic Control System for Winnipeg Unattended Pumping Station).*

Mr. Hurst has been associated with the City of Winnipeg Engineering Department as resident engineer, office engineer, engineer of water works, assistant city engineer and city engineer. He has also been with the Winnipeg Sanitary District and the Winnipeg-St. Boniface Harbour Commission. Mr. Hurst has held executive positions in the Association of Professional Engineers of Manitoba, The American Water Works Association, The American Public Works Association and is a member of numerous other professional associations.

F. G. Denson, M.E.I.C., B.Sc., Civil (Manitoba '50), Engineer of waterworks and sewage, City of Winnipeg Engineering Department, Winnipeg, Man. *(Supervisory and Automatic Control System for Winnipeg Unattended Pumping Station).*

Prior to obtaining his degree Mr. Denson was with the Winnipeg Electric Company for seven years and was stationed in England with the R.C.A.F. as a pilot during the war. He joined the Winnipeg Waterworks Department as Distribution Engineer in 1950. He is a member of the Association of Professional Engineers of Manitoba, the American Water Works Association and the Canadian Institute on Sewage and Sanitation.

R. A. Forrester, B.A.Sc., Civil (U. of T. '40), Project Engineer, The Hydro-Electric Power Commission of Ontario, Toronto, Ontario, *(Silver Falls Project).*

Mr. Forrester began his professional career with the Department of National Defence as field engineer on airport construction. During the war he served overseas with the Royal Canadian Engineers. Employed by H.E.P.C. since 1945, he has been project engineer for several hydraulic generating stations.

C. W. Hodgson, M.E.I.C., A.M., I.M.E., Director and Chief Engineer, Ewbank & Partners (Canada) Ltd., Toronto, Ont. *(Salient Mechanical Design Aspects of the Selkirk Generating Station).*

Before the Second World War Mr. Hodgson was with Merz & McLennan, Consulting Engineers. He served as an engineer officer in the Royal Navy during the War. He then joined the Central Electricity Authority at Nottingham, England, and was later appointed a generation engineer (construction). Mr. Hodgson is a member of the Institution of Mechanical Engineers.

R. W. Wilson, M.E.I.C., B.Sc. (Dalhousie '50), radio systems engineer, Maritime Telegraph and Telephone Company Ltd., Halifax, N.S. *(Application of Microwave Radio Links).*

Mr. Wilson has been with his present company for the past ten years and is in charge of design layout and application of all company radio facilities in Nova Scotia and those of the Island Telephone Company in P.E.I. He is a member of the Association of Professional Engineers of Nova Scotia and the Institute of Radio Engineers.

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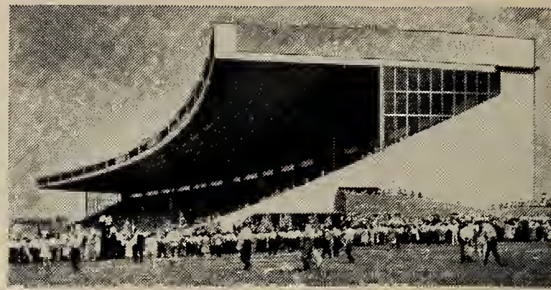
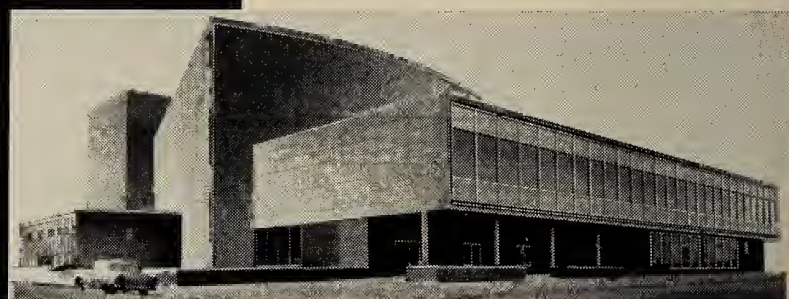


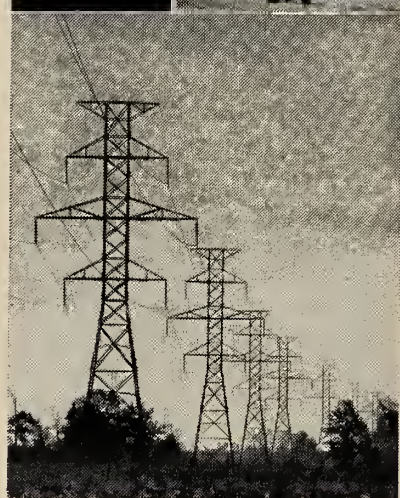
The Grandstand at the Canadian National Exhibition

The Princess Margaret Bridge at Fredericton, N.B.

Since 1900 the Canadian Bridge Works has been a major industry in Canada. Our engineers and skilled craftsmen design and fabricate structural steel for bridges, towers, grandstands and modern buildings for erection across the country, and in other parts of the world . . . Noted for its highly specialized services and facilities the Canadian Bridge Works ranks as a leader in the structural steel industry.



The Cleary Civic Auditorium on the Waterfront, Windsor.



Typical Transmission Towers seen in every Province across Canada.

• HIGHWAY AND RAILWAY BRIDGES • TRANSMISSION TOWERS • RADIO AND TV TOWERS • STEEL BUILDINGS • MINE HEADFRAMES • VIADUCTS • TURNTABLES • MACHINERY FOR MOVABLE BRIDGES • RIVETED AND WELDED PLATEWORK • WELDED MACHINERY BASES AND BEDPLATES

DOMINION STEEL AND COAL CORPORATION, LIMITED

DOSCO

CANADIAN BRIDGE WORKS

WALKERVILLE, ONTARIO VILLE LASALLE, QUEBEC

THE FOLLOWING SUMMARIES OF ENGINEERING ACHIEVEMENT IN CANADA DURING 1959 ARE BASED ON INFORMATION RECEIVED IN THE ANNUAL REPORTS OF CHAIRMEN OF THE EIGHT DIVISIONS OF THE INSTITUTE'S COMMITTEE ON TECHNICAL OPERATIONS

ENGINEERING PROGRESS

1959

Mining Engineering

THE mineral industry continued to grow in volume and value during 1959. Preliminary estimates by the Dominion Bureau of Statistics indicate a value of production of nearly $2,390-million and a new high D.B.S. index (1949 = 100) of physical volume of production at 252.0; a 10% gain over 1958.

The total figure of value includes metals ($1,359-million), non-metallics ($176-million), structural materials ($314-million), and coal ($73-million); petroleum production of some 184,593,000 barrels, and natural gas output of 427,800-million cubic feet (an increase of over 26% over 1958), were valued at about $467-million.

Gains were shown among all the important minerals except gold, lead, and coal. Largest increases in value were recorded by nickel ($63-million), copper ($59MM), iron ore ($60MM), and uranium ($49MM). The largest percentage increase was shown by iron ore (55.6% in volume, 47.6% in value).

The future of uranium is clouded with uncertainty. The original contracts were to expire in 1962 and early 1963. The United States government has announced its decision not to take up the options on production after that time, but there has been a stretch-out in the delivery time. Contracts to supply uranium oxide may now be transferred and a company acquiring an uncompleted contract may proceed to fill that contract until 1967. This stretch-out has rescued some of the mines that had contracts which formerly were not transferrable and that did not have the ore enabling them to meet the contract.

The physical output of iron ore may be down nearly 6 million tons because part of the U.S. market was closed off by the strikes in the steel industry. The opening of the St. Lawrence Seaway may have far-reaching effetcs on the iron ore industry. The outlook is that there will be an annual production of 20 to 30 million tons of ore tributary to the north shore of the St. Lawrence. Whether this will move to the mid-continent via the Seaway or overland from Contrecoeur below Montreal or from Philadelphia, will depend on the relative cost of each method of shipping. 1959 was not a good year to judge the impact of the Seaway on the iron ore trade and vice versa because of U.S. steel strikes. Canada will not benefit to the fullest possible extent from Seaway trade unless shipping is provided that can work the Seaway routes during the open season and ocean traffic during the closed months.

The status of the industry in the different provinces varied widely, and here are considered only some of the outstanding events in provinces where there was a marked change.

Newfoundland

The Atlantic Coast Copper Company is developing old reserves at the old Little Bay Copper Mine in the Notre Dame Bay area. The results are encouraging.

A test mill was installed during the year on the Asbestos property near Baie Verte in the Cape St. John area. This should become an important source of asbestos.

The American Smelting and Refining Company, Buchans Unit, continued production at a reduced rate because of the over-supply of zinc in the world markets. The MacLean shaft designed for 4,000 feet was nearing completion at the year's end.

Iron Ore. The first increase in the iron ore production in Newfoundland-Labrador will come from the Iron Ore Company installation at the Carol Lake Project which will probably attain 6 million tons of concentrate production per year. The Wabush Ore Company was preparing to go into the pilot plant stage preparatory to putting in a plant to produce about 5 million tons of concentrate per year. The two companies combined to build a railroad into the Wabush Lake area about 40 miles from Mile 227 of the Quebec, North Shore and Labrador Railway and it was under construction during the year. Power is expected from the Grand Falls on the Hamilton River. Capital expenditure in the area will be close to $300 million.

Nova Scotia

The coal industry in Nova Scotia continued to be in difficulty. The mines are remote from coal-consuming centres and the markets of the Maritimes are too thin to encourage large-scale manufacture.

A new salt mine with a capacity of 3,000 tons per 8 hours was opened at Pugwash by the Malagash Salt Limited.

Other minerals of importance to Nova Scotia are barytes, used mainly in drilling muds by the petroleum industry, and gypsum, of which the province's production represents about 80% of total Canadian output.

Over 1200 prospecting licences were issued during 1959, more than half of these to major Canadian companies.

New Brunswick

There was no remarkable advance in mining activity in New Brunswick during 1959, though there was a considerable improvement in conditions over 1958. Total value for the year was about 13% above 1958, with coal showing a 20% improvement in volume to about one million tons.

General prospecting and exploration increased more than 50%, a developing interest being shown in base metals.

Quebec

A large part of the increase in Canadian iron ore production will come from Quebec. During 1959 the Quebec-Cartier Mining Company was building a 193 mile railway to Lac Jeannine. It was installing harbour facilities at Shelter Bay and building two towns which will have a population of about 6,000 people.

The second mine in Chibougamau, the Copper Rand, was nearly ready for production at the year's end. Prospecting and exploration continued in the Mattagami area northwest of the Chibougamau area. Eventually this area will be a large producer of zinc. There was renewed and successful prospecting in the Noranda and Val d'Or areas.

Ontario

Mineral production in Ontario, in 1959, reached a record peak estimated at over $962-million with an increase over 1958 of $161.5 million. Metallic minerals showed the greatest gain.

A new iron producer, the Lowphos Ore Company, started its beneficiation plant near Capreol, Ontario, in May.

A salt mine was opened at Goderich by the Sifto Salt Limited. This mine has a capacity of 4,400 tons per shift.

The strike of the International Nickel Company's employees was settled early in the year and production was resumed. Reserve stocks of nickel had been lowered, and that, with the political upset in Cuba, completely changed the near-term outlook for nickel demand.

Manitoba

The outstanding mineral operation in Manitoba continued to be the Thompson development of the International Nickel Company. The town of Thompson now covers a 3000 acre site on the Burntwood River. The mining project will be the second largest nickel producing operation in the world, after the Inco plant at Sudbury, Ont.

Saskatchewan

Potash is the main item of interest in Saskatchewan's mineral industry. First Canadian production of potash came from the Patience Lake operation of Potash Company of America in 1958. This company has spent over $20-million on its mine and surface plant, and hopes to produce some 600,000 tons of finished product a year.

International Minerals and Chemical Corporation (Canada) Limited started to sink a shaft to potash deposits near Esterhazy, northeast of Regina, during the year. Other companies are testing leased areas.

It is estimated that, of 17,700-million tons of potash in the province, about 6,400-million tons are recoverable.

Alberta

Petroleum and natural gas are by far the most important contributors to the mineral industry of Alberta, in which coal, sulphur, salt, and structural materials also play a part. Increased production of petroleum, natural gas, and coal helped to raise the value of mineral production in Alberta to an estimated $378.1 million.

The potential production of petroleum and natural gas is much higher than present figures, but is restricted by various controls. Many verbal battles raged during 1959 over the export of natural gas from Alberta, and it was not until the beginning of 1960 that prospects brightened when the National Energy Board approved several applications to export gas.

Sulphur production continued at much the same level in 1959 as in 1958 ($1.8-million), but is almost certain to increase, since it is derived from the processing of sour natural gas. Recoverable sulphur from natural gas reserves in Alberta has been estimated at 82,000,000 long tons.

British Columbia

Though the mainstays of the B.C. mineral industry, lead and zinc, showed a combined increase in value of only about 1% (1959 over 1958), the industry showed an overall increase in value of over 5%. This was partly due to greater diversification in operations and to an increase in the petroleum industry which more than offset a decline in coal.

Iron ore output was about 855,000 tons, the bulk of which was exported to Japan. During the year, the Consolidated Mining and Smelting Co. of Canada Limited started construction of a $22.5-million smelter at the Sullivan Mine, Kimberley. The first phase is scheduled for completion in 1961; annual capacity from this is to be 100,000 tons of steel and 36,500 tons of pig iron from sulphide concentrate. Sulphur from the operation will continue to be used in Cominco's fertilizer plants.

Value of sulphur from smelter gas continued at nearly the same figure as in 1958 ($1.65-million), but the value of sulphur from petroleum sources rose remarkably from less than 2% of this figure to about 47%, at over $776,000.

Yukon and Northwest Territories

Great interest was shown in the Yukon and Northwest Territories during 1959, particularly concerning petroleum. Though actual drilling activity was considerably less than in other post-war years, 1959 saw the second well to be drilled in the Yukon. This well proved to be successful.

Considerable exploration activity continued by petroleum and other mining interests. Both government and private interests were engaged in various surveys, including mapping and other investigations of the continental shelf and Arctic islands.

The Canadian chemical Industry

in 1959 continued to show progress, but fell far behind its past record. Although production showed a small increase, employment decreased slightly which may be attributable to capital investments for effecting improvements in processing. Chemical prices in 1958 increased about 3.2% except for fertilizer and coal tar products which changed only slightly. Thus the value of the chemicals and allied products industry increased 3% to $1,300 million.

The chemical industry is highly competitive within itself and imports of chemicals have been increasing with the result that total exports decreased in 1958.

The Canadian chemical market expanded about 4% during 1958 and manufacturers' shipments showed an average growth as was forecast for 1959.

Major industrial expansion in the Canadian Chemical Industry is given in the accompanying tabulation.

Petroleum and petrochemicals. In addition to the chemical industry, the petroleum, natural gas, and petrochemical industries are also of concern to the chemical engineering field.

Petroleum refinery capacity in Canada increased nearly 6% in 1959 over 1958 to about 878,000 barrels a day.

New Brunswick

Work progressed on the new 40,000 barrel/day (b/d) refinery of Irving Refining Limited at St. John. This will include a hydrogen plant, the hydrogen to be used for desulphurizing processes.

Quebec

Texaco Canada Limited added a hydro-treater at their Montreal East refinery to remove sulphur from middle distillates. The unit has a capacity of 350,000 gal. of oil a day, from which 2 to 15 tons of sulphur are recovered daily.

Canadian Industries Limited started construction at Beloeil of a plant (the first in Canada) to manufacture pentaerythritol tetranitrate (P.E.T.N.) used in various blasting explosives.

Carbide Chemicals Company, Division of Union Carbide Canada Limited, initiated the third major expansion of polyethylene production at its Montreal East plant, to be completed early in 1960. The Visking Division started construction of a polyethylene film plant at Cowansville.

Shell Oil Company of Canada Limited introduced production of an odourless solvent from their petrochemical plant at Montreal East.

Construction proceeded on a new complete refinery for BP Canada Limited at Ville d'Anjou, east of Montreal. This plant will have a capacity, initially, of 25,000 b/d and is due to go on stream about April 1960.

Also in the Montreal East area, a gas concentration unit was commissioned at the Canadian Petrofina refinery in mid-1959.

Ontario

Rio Tinto Dow Limited started operation at Elliot Lake of a $1-million plant for the recovery of thorium from waste solutions resulting from uranium recovery.

Hercules Powder Company (Canada) Limited began construction of the first plant for the fractional distillation of crude tall oil. The plant will produce resin and fatty acids.

There were several developments in the Sarnia area. The Canadian Oil Companies Limited refinery added a new 20,000 b/d crude unit, hydrogen-desulphurizing unit, and other facilities in a major expansion program. At the nearby plant of Ethyl Corporation of Canada Limited a new plant was under construction for production of ethyl chloride and ethylene dichloride. Dow Chemical of Canada Limited were working on a new plant to produce high density polyethylene.

Du Pont of Canada Limited were also interested in polyethylene with their new plant under construction at Corunna, near Sarnia. As in the case of the Dow plant, technical data were closely guarded. Du Pont started production of polyethylene film from a new plant at Whitby, and opened a new nylon tire yarn plant at Kingston, accompanied by expansion of nylon intermediates capacity at Maitland, at a cost of $7.5-million.

Canadian Industries Limited started construction of a $500,000 plant at Cornwall for production of caustic potash which will be used in the manufacture of soaps and detergents, liquid fertilizer, and in oil refining.

Hardifoam Products Limited, of Toronto, is a new firm entering into the manufacture of polyurethane foam with an initial capacity of 5-million pounds a year.

Manitoba

The major development during the year was the start of construction of the Thompson nickel refinery by the International Nickel Company. Part of a great mining and refining operation which will be the second largest nickel producer in the world when completed, the refinery will cost some $25-million and have a capacity of up to 75-million pounds a year.

In the petroleum refining field, a $2,600,000 HF alkylation plant was completed at the Winnipeg refinery of Imperial Oil Limited.

Alberta

Sulphur production from natural gas was on the increase during 1959. Texas Gulf Sulphur Company started operations at a plant at Okotoks, under agreement with Shell Oil of Canada Limited and Devon-Palmer Oils Limited. Plant capacity is 100,000 tons a year. British American Oil Company Limited was also at work expanding its sulphur-producing facilities at Pincher Creek and Nevis. California Standard, Home Oil, and others built a $3-million gas processing plant near Red Deer, at which sulphur will be produced.

Imperial Oil Limited opened its virtually completely rebuilt oil refinery at Calgary and was working on a new HF alkylation plant at the Edmonton refinery. Other refinery expansion took place at plants of British American Oil, Calgary, and Texaco Canada Limited. A start was made on a new plant for Canadian Oil Companies near Red Deer, to process mainly gas condensate.

The Red Deer area of Alberta has been in the news several times as a possible major centre for petrochemical operations. Polymer Corporation Limited may soon have a butadiene plant in the area with a capacity of 25,000-30,000 tons a year.

British Columbia

Celgar Limited, a subsidiary of Canadian Chemical and Cellulose Company, constructed a 500-ton/day pulp mill which will be supplied with chlorine and caustic from the Cominco plant at Trail, some 28 miles away.

Production of sulphur from natural gas increased considerably during 1959. At the gas processing and oil refining plant of Phillips Petroleum Company, at Taylor, work started on a new crude unit, catalytic cracker, and alkylation unit, for completion in 1960.

New Industrial Process

A new industrial process, developed by Dr. Wm. Gauvin of the Pulp and Paper Research Institute of Canada, for the treatment of wastes from pulp mills has been found to be successful in the treatment of sewage. The process is called the Atomized Suspension Technique or AST. Basically AST involves the atomizing and spraying of material in fluid form into the top of a tower. Waste can be destroyed and valuable components separated from wastes.

The AST sewage installation at Beaconsfield, near Montreal, has been pronounced a success and all Canadian governments, municipal, provincial and federal may use the process royalty-free.

Uranium Industry

The Canadian uranium industry, which comprises 21 working mines and 16 ore processing plants, finds itself in a critical position due to the uncertainty of U.S. intentions of contract renewal after 1962-63.

Canadian uranium oxide production is about 16,000 tons per year, while world civilian power requirements will not likely exceed 5,000 tons in 1962 and could reach 9,000 tons by 1965. This market must be shared by Canada, United States, S. Africa, and to a lesser extent the Belgian Congo, Australian, and French interests. However, the long-term picture is encouraging as civilian requirements are estimated at 35,000 tons by 1975.

Future of the Chemical Industry

The provinces of Ontario, Quebec and Alberta continue to expand their chemical interests. Manitoba has engaged the consulting firm of Arthur D. Little (Cambridge, Mass.) during the past four years to conduct feasibility studies for certain chemical

MANUFACTURERS' SHIPMENTS BY CHEMICAL GROUP
(MILLIONS OF DOLLARS)

Group	*1958*	*est. 1959*	*per cent change*
Acid, Alkalis and Salts	257	284	+11
Adhesives	14	21	+15
Fertilizers	84	83	− 1
Medicinal and Pharmaceutical	150	161	+ 7
Paints and Varnishes	143	145	+ 1
Primary Plastics	93	100	+ 8
Soaps, Washing and Cleaning Compounds	133	143	+ 8
Toilet Preparations	53	56	+ 7

industries. At present local markets are small and large volume outlets are sufficiently distant to make transport costs a restraining factor.

The capital outlay for expansion of the chemical industry as planned for 1960, which will take in some instances till 1962 to complete, is about $440 million.

There are few plans for the production of chemicals not previously made in Canada. Exceptions are caustic potash, refined tall oil, and maleic anhydride. The absence of new products is due to a limited market, foreign competition, and unfavourable duty rates that have to be faced.

Electrical Engineering

In the electrical engineering field automation and automatic control have been undergoing intensive study.

Pioneer work is being done in the field of extra high voltage power transmission lines. Another Canadian development has been the provision of an aluminum prefabricated substation.

Improvements in rotating electrical machinery continue to be made, and greater use of automatic control of facilities is in evidence in public utilities.

Economics plays an important role in the planning and operation of hydro-electric systems. An exhaustive study in Manitoba may be of interest to other provinces (E.I.C. annual meeting paper).

The development of epoxy insulating resins promises to make changes and improvements in the design and manufacture of electrical equipment just as it has done in the case of electrical components. The application of printed wiring continues to expand.

Several papers on electrical engineering subjects will be given at the E.I.C. annual meeting, including: two papers on automatic control; one on extra high voltage transmission, featuring the use of aluminum towers; evolution in the field of rotating electrical machinery; automatic control at a major waterworks; electronic control via communication networks; application of microwave links; and the economic study in Manitoba.

Extra High Voltage Transmission

Transmission line voltages have risen quite rapidly since the inception of the electrical power industry. In the 1930's a level of 220-kv. was familiar; at present there are lines operating in North America up to 362-kv. In Europe, even higher voltages are in operation, up to the Russian line of 525-kv., which may soon be exceeded if current Russian plans for very long distance transmission are carried out.

Both in Russia and North America, engineers have considered transmission over a grid that would cover more than one time zone. Briefly, this could enable peak loads in one area to be supplied by plants in another time zone, in which there was an off-peak operation. Of more immediate interest is the possibility of making economical use or large amounts of power from relatively remote sources, such as might be done across Ontario or from the Peace River, in B.C., and the Hamilton Falls site, in Labrador, rather than building thermal stations close to load centres.

Ontario Hydro has started extra-high-voltage tests at Coldwater, some 80 miles north of Toronto, to determine the economics of building and operating a line at 460-kv. for transmission of large amounts of power from remote sources.

Communications

The TD-2 radio relay system used on the Trans Canada microwave network operates in the 4000 Mc. band and carries 3000 telephone circuits or five two-way TV network channels over distances of 4000 miles. However, a system is being investigated that operates in the 6000 Mc. band and could carry up to 13,320 telephone circuits or six two-way TV channels over similar distances. Equipment operating in the 50,000 Mc. band would provide about 133,000 telephone circuits, though the signal could not readily be transmitted through the atmosphere. Experiments are being done in the Bell Telephone Laboratories to determine if signals of this frequency can be transmitted via a suitable waveguide.

Work proceeded in Canada during 1959 towards the extension to Montreal and elsewhere (in March 1960) of direct distance dialling, by which an individual caller can dial a normally long-distance call without the help of an operator. A multi-frequency pulsing system is used, instead of the d.c. loop used between instrument and telephone office in normal local dialling. Long-range plans envisage the replacement of the mechanical dial by electronic type dial switching systems, making extensive use of transistors.

Communication in northern areas is complicated by conditions such as the aurora. The troposphere scatter technique is widely used for defence communications and in the Quebec-Labrador system (*The Engineering Journal*, April 1959).

Hydro-Electric Engineering

THE development of the hydro-electric generating industry in Canada during 1959 was surveyed in some detail in the October 1959 issue of *The Engineering Journal*. The present report is necessarily a rather brief review of the major developments during 1959. Several papers to be presented at the 1960 annual meeting of E.I.C., in May, will discuss certain aspects of the industry in greater detail.

British Columbia

Work continued during the year on the B.C. Electric Co. Bridge River No. 2 plant of four units each of 82,000 h.p. The second stage involves the completion, in the spring, of Mission Dam, a 3-million cu. yd. earthfill structure extending 1200 ft. across the Bridge River Valley. Total capacity of Bridge River area plants will be 680,000 h.p.

Major hydro-electric development during 1959 for B.C. Hydro was completion of the Ash River unit of 35,000 h.p. Plans were made for future developments, and studies showed that more than one-million h.p. would be available from the Clearwater River system, north of Kamloops.

One of the most controversial subjects for some time has been the development of the Columbia River. B.C. Hydro has been designated by the provincial government to develop the Columbia in Canada, and reserves have been granted on crown lands at the High Arrow damsite of Lower Arrow Lake and on Duncan Lake damsite at the head of Kootenay Lake.

Perhaps no less controversial is the subject of the Peace River development, with which the name of Wenner-Gren has been closely associated. The largely British- and Canadian-backed Peace River Power Development Company Limited continued with various studies during 1959 to complete a report called for under an agreement made with the B.C. government in 1957. This report was filed with the Comptroller of Water Rights at the end of 1959, as required. The plan proposes two dams: the main one, Portage Mountain Dam, would impound 88-million acre-feet of water (or five to six times the total hydro-electric storage in B.C., Washington, and Oregon). The second dam, Site No. 1 Dam, would be near the foot of the Canyon. Combined potential from the two sites would be over four-million h.p., and another one-million h.p. would be available from other sites on the Peace River between Site No. 1 and the Alberta border. Transmission would be by a 500-kv. line between the Peace River and the B.C. Electric system at Lillooet.

If the report is approved, and other formalities completed, the Peace River Company might start driving the pilot tunnel by midsummer of 1960, and could expect to produce 750,000 h.p. by 1968.

Alberta

It is estimated that there is a potential of five-million h.p. on the Peace River in Alberta, though no studies have been made of actual development sites. The advance in high-voltage transmission techniques could make power available from the somewhat remote Peace River at economical rates.

Saskatchewan

During the year, a seventh unit was added to the Island Falls development on the Churchill. This added 19,000 h.p. to the existing 106,500 h.p. The plant is operated by the Churchill River Power Company.

The Squaw River development on the Saskatchewan River is an assured project, but is only at the stage of clearing and camp construction. Plans call for the installation of six 46,000-h.p. Francis turbines operating under a head of 105 ft. The estimated energy production is 1-billion kwh., and the cost about $45 million.

The proposed South Saskatchewan River Dam is to be built jointly by the Prairie Farm Rehabilitation Administration and the province. Plans call for three hydro-electric units of 85,000 h.p. each operating under a normal head of 180 feet.

Manitoba

During 1959 construction started on the Kelsey power plant on the Nelson River. The construction difficulties associated with this project were out of the ordinary, especially the foundation conditions at the rock fill dam and the sand dykes. (The plant is the subject of a paper at the E.I.C. annual meeting in May.)

The Grand Rapids development on the Saskatchewan River calls for a 378 Mw. station of four units with a normal head of 120 feet. The estimated cost is $112,000,000, apart from transmission costs of about $30 million.

Ontario

The Silver Falls station on the Kaministikwia River, 30 miles northwest of Port Arthur, was completed during 1959. This is a single unit of 35,000 kw. operated by remote control from the lakehead. It features a two-mile tunnel through granite, concrete-lined to a finished inside diameter of 14 ft. 6 in., as well as a surge tank of stand-pipe type, 180 ft. high and 38 ft. outside diameter. The cost is said to have been $16,500,000. (Papers on the station and tunnel are to be given at the E.I.C. annual meeting.)

In 1959, nine additional units were installed at the Robert H. Saunders station of the St. Lawrence development, to complete the station. There are sixteen units in all at the station, each of 72,500 h.p., with an operating head of 81 feet.

The Red Rock Falls station was under construction on the Mississagi River in northern Ontario. This is a station of two units of 26,000 h.p. each operating under a head of 93 feet. The two units are due to go into service late in 1960.

Construction also started on the Otter Rapids station on the Abitibi River. This consists of four units of 66,000 h.p. each. Two units are scheduled for 1961, two for 1963. Normal operating head is 107 feet.

Quebec

The Shawinigan Water and Power Company's Beaumont project was operating during 1959. Six units of 55,000 h.p. each operate under a head of 124 feet. This is now the eighth plant in active service on the St. Maurice River.

During the year, construction started at the Carillon plant on the Ottawa River. This plant of twelve 60,000-h.p. Kaplan units will operate under a 60-ft. head.

Work continued on the Hydro-Québec Bersimis II development, where three 171,000 h.p. units were completed; two more are to be completed in 1960.

First power was produced from the Chute-des-Passes project of the Aluminum Company of Canada. (This project is discussed in some detail in *The Engineering Journal*, January 1960, p. 39.)

New Brunswick

The third unit at the N.B. Electric Power Commission plant at Beechwood is to be started. During the year the N.B.E.P.C. took over the Grand Falls plant of Gatineau Power Limited, thereby adding four units of 20,000 h.p. each to the system; normal operating head is 125 feet.

The revival of interest in the Passamaquoddy Tidal Project, and hence in Rankin Rapids, caused the N.B. Electric Power Commission to concentrate on their studies of the optimum development of the St. John River. The engineering staff are more than ever convinced that integration of hydro-electric with thermal power, as they advocate, is the proper procedure to get the highest potential and maximum overall energy.

Nova Scotia

In 1959 the Nova Scotia Power Commission started construction of both the Sissiboo Falls and Weymouth developments which they plan to bring on line in 1960. These are both single unit plants, the former of 6,000 h.p., the latter of 9,000 h.p.

Civil Engineering

CIVIL engineering design and construction continued at a high level of activity during 1959.

Highway construction continued as a major element in engineering activity in all parts of Canada. Incidental to this, extensive new highway bridge construction was also continued.

Work progressed on runways at Inuvik, at the mouth of the Mackenzie River, at Prince Rupert, and at Edmonton, and on terminal facilities at Montreal and Edmonton, all among the larger of such projects.

Institutional building continued on a substantial scale, with perhaps the major expansion in this type of activity being in the field of University buildings in all parts of Canada.

Construction in far northern areas was largely confined to several big projects and involved considerable specialized design.

Municipal engineering was highlighted principally by the installation of new sanitary facilities in small communities, and by the completion of two or three advanced designs for far northern conditions.

In the field of earth dam construction, activities were marked by a number of extraordinarily large dams, with unusually difficult design conditions, particularly in western Canada. The most spectacular event in this field was the start of construction on the South Saskatchewan project, but designs were also brought close to completion on the Squaw Rapids development in Saskatchewan and the Brazeau project dam in Alberta.

In the field of mining construction, major activities continued in northern Quebec, at the International Nickel development in Manitoba, and at the Caland Ore project at Steep Rock Lake, in western Ontario.

The year also witnessed the formal openings of the highly publicized and monumental projects, the St. Lawrence Seaway and the Deas Island tunnel in Vancouver.

Highway Engineering

Petroleum and natural gas developments in the north have already led to the construction of a road in the Yukon to serve the Eagle Plains development; this will be Canada's most northerly road for a while. A road linking Alberta centres with the Arctic Ocean has been predicted. Heavy expenditures are foreseen for Yukon and Northwest Territories during the next few years.

Both the Canadian Good Roads Association and the Canadian Construction Association play a large part in promoting the development of an adequate roads system in Canada, but both agree that there is a great need for improvement.

The CGRA, as the co-ordinating agency for road research in Canada, has published a list of all road research projects in Canada. About $1 million were spent on research in 1958. However, the CGRA finds that Canada lags well behind the United States highway industry and other private industries in its rate of investment in road research.

Work continued on the Trans-Canada highway, and it is expected that most of the project will be completed by the time the present agreements between the provincial and federal governments expire at the end of 1960.

Railways

The railways have been very active in constructing new facilities. Canadian National Railways were working on 4 major hump yards, in Montreal (costing $28.5-million), Moncton ($15-million), Winnipeg ($24-million), and in Toronto. The Montreal yard is electronically controlled and will be the largest of its kind in North America. Many extensions to rail lines were continued, and considerable work was involved in constructing new facilities for traffic in the St. Lawrence Seaway area around Montreal. Canadian Pacific Railway also were engaged in construction of yard facilities at Lancaster, N.B., Agincourt, Ont. Construction of 'piggy-back' terminals was carried out at various centres.

St. Lawrence Seaway

Much has been published about the construction of the St. Lawrence Seaway.

There was a marked increase in traffic during the 1959 season, despite the fact that cargo tonnage through the Montreal to Lake Ontario section was actually down 23.8% in April compared with the 1958 season, and down again in December. These are months of relatively minor traffic, and the net increase for 1959 over 1958 was 73%, with a total of 20.35-million cargo tons. This increase was also reflected at the Welland canal, which showed a gain of 27.6%, with 27.16-million tons of toll traffic in 1959.

Public Works

The Federal Department of Public Works is one of the largest spenders on construction work in the country. Construction of highways, bridges, other highway structures, harbours and navigation facilities are among their projects.

About $53-million was paid to provincial governments during the calendar year 1959 towards the Trans-Canada Highway; grading was completed on 564 miles, paving on 269 miles, and 70 structures of various types were built. Direct expenditures on the Trans-Canada Highway through the National Parks were some $12-million, and on other roads in the parks another $10-million. Work in the Northwest Territories and Yukon amounted to a further $7.3-million.

A major undertaking started in 1959 was the modernization of the harbour at St. John's, Newfoundland. New wharves, transit sheds, and berthing facilities for large ships will be built, as well as new access roads. Another large harbour development is that at the Lakehead, at a site between Port Arthur and Fort William. Three berths are being built at first, though there is room for ten in future. One of the berths has been designed for handling deep-sea ships.

Another proposed harbour development, in which federal participation may be expected, is that at Moosonee, on James Bay, in northern Ontario. Preliminary work has already been carried out by the Ontario government and Ontario Northland Railway, which has a rail link between Moosonee and Cochrane, and which is expected to spend some $20 to $30 million on development.

A new harbour, to be known as Port Cartier, is being carved out of rock on the North Shore of the St. Lawrence as part of Quebec Cartier Mining Company's iron ore development in northern Quebec.

Water Resources

The South Saskatchewan River project will have the largest rolled-earth fill dam in Canada, and one of the largest of its kind in the world. It will rise 210 ft. above the present river floor, and extend laterally for almost 3 miles. Five 20-ft. diameter tunnels, averaging 4050 ft. long, will be used for diversion of water during main fill construction, and will subsequently be converted to supply water for hydro-electric power development and for regulating river flow.

Several flood-control projects were under consideration in Manitoba. These were a 26-mile long Greater Winnipeg floodway, a dam on the Assiniboine River near Russell and another near Holland, and a diversion from the river near Portage la Prairie to Lake Manitoba. These projects would eliminate flood damage in the Red and Assiniboine river valleys.

In Ontario, the Water Resources Commission has been active in developing and controlling resources since its formation in 1956. Of great importance is the work of the Commission in controlling pollution of waters by municipalities and industries. Ontario has a particular problem arising from the existence of international boundaries with the United States in the middle of narrow waterways (for example, Niagara, Windsor, Sault Ste. Marie, Sarnia). In protecting these waters, the Ontario Commission works closely with the International Joint Commission.

Defence Construction

Under an agreement between Canada and the United States, refuelling bases are being built at Frobisher Bay and Churchill, Man., and at Namao and Cold Lake, Alta. Work proceeded towards the construction of bases in northern Ontario and Quebec for the Bomarc guided missile.

Bridge and Structural Engineering

THERE was much activity in construction of bridges and other engineering structures during 1959. Included among major bridge projects were the Second Narrows Bridge in Vancouver, the Peace River highway bridge in northern British Columbia, and the Dunvegan suspension bridge across the Peace River in northern Alberta. Construction was also started on the Port Mann bridge across the lower Fraser River in the Vancouver area.

Average monthly shipments by the steel fabricating industry in 1959 were 47,000 tons, representing an increase of 15% over the 1958 rate. About three-quarters of these shipments is for structural applications.

Bridge Developments

The Port Mann bridge will carry the Trans-Canada Highway across the Fraser River about 15 miles east of Vancouver. To cost about $25-million, the bridge will be 6900 ft. long with a centre span of 1200 ft., side spans of 360 ft., and a vertical clearance of 145 ft. above high water. A particular feature is an orthotropic deck of steel plate only ½ in. thick, with stiffeners and cross girders to form an integral structure saving considerable weight.

A smaller, but interesting, development also in the Vancouver area is the Capilano Canyon bridge, over the Capilano River. The 615-ft. long structure will incorporate the longest concrete fixed arch span in the Commonwealth (345 ft.).

In Ontario, a contract was let in 1959 for construction of the $3.7-million vertical lift bridge at Burlington, on the Queen Elizabeth highway. The largest and longest of its type in Canada, the bridge will be 370 ft. long, 51 ft. wide, and have suspension towers over 200 ft. high. Also in Ontario, a start was made on a high-level bridge on the Q.E. Highway to cross the Welland Canal at St. Catharines. Yet another project in the province is the $18-million international bridge to link the two towns of Sault Ste. Marie, in Ontario and Michigan.

The provinces of Quebec and New Brunswick, and the federal government, are helping to finance a bridge across an arm of the Baie des Chaleurs between Campbellton, N.B., and Pointe à la Croix, Quebec. There will be an 800-ft. clear span in the centre to allow passage of log booms from the Restigouche River.

Among projects in the north, a $2-million contract was awarded in 1959 for construction of bridges over the Pelly and Stewart Rivers, in the Yukon, and improvement of the Yukon River bridge at Carmacks. The first two bridges are on the Whitehorse-Mayo highway, 160 and 220 miles north of Whitehorse, respectively.

Large Buildings

Heavy investment in new buildings was noted during 1959. Montreal and Toronto were to the fore, though much work was done in other centres. A few large office projects in Montreal represent over $200-million in capital investment. The Place Ville Marie development accounts for $75-million, and a further $42-million will be spent on the Windsor Plaza development of the Canadian Bank of Commerce which will be the tallest building in the Commonwealth. The Canadian National Railways are building a 17-storey structure for new office accommodation, and other large projects include the 31-storey C-I-L House of Canadian Industries Limited. The centre of the Place Ville Marie project is a 42-storey cruciform office building.

Also in the Dorchester Street area of Montreal, Hydro-Quebec's new sub-station and headquarters building was excavated for and some 8-000 tons of steelwork were erected.

In Ontario, contracts for new hospitals and similar institutional buildings let in 1959 amounted to about $40-million. The federal government has several large projects under way for government buildings in Ottawa and in other centres, buildings include new airport terminals.

At Dorval airport, near Montreal, Trans-Canada Airlines has been at work on its new $20-million aircraft maintenance facilities. The main hangar incorporates what is said to be the largest single-cantilever roof in North America. The roof is 835 ft. long, 50 ft. above ground level, and extends 175 ft. out from the main columns. It consists of 28 conventional trusses spaced at 30-ft. centres, supported from above by diagonally-placed suspension bars pin-connected to the top chord and to the tops of the main columns, which also carry the inner ends of the trusses. The columns are 110 ft. tall; they provide a clearance of 50 ft. below the trusses. Loads on the overhanging roof are balanced behind the main column by tying into the building structure which contains two floors of workshop and offices. The hangar will accommodate 5 Douglas DC8 aircraft side by side.

Housing

1959 housing construction was slightly less than in 1958: main figures were (1958 in parentheses), starts: 141,345 (164,632); completions: 145,671 (146,686); under construction at year-end: 81,905 (88,-162).

Wider use of new materials is indicated; such as aluminum, plastics, laminated wood. Prefabrication has been used to a greater extent for some aspects of housing construction.

Management

EFFICIENT management may make the difference between success and failure in a great variety of enterprises, large and small, in industry and commerce. Correct management is as important to engineering undertakings as to any other field.

Aware of the importance of management, the Management Division, Committee for Technical Operations, of the Engineering Institute of Canada was formed in April 1959. Among the aims of the Division is the establishment of a body of members who have a proven interest and ability in management, chosen from all parts of the country.

Co-operation with other organizations interested in management is necessary. The Division works closely with the Canadian Management Council (CMC), of which the E.I.C. was a founder member. CMC represents Canada on the International Organization for Scientific Management (CIOS), which has a membership of 29 countries.

The Canadian chapter of the American Society for Quality Control will also co-operate with the Division, and are to contribute a paper "Statistical Quality Control as a Management Tool" at the annual meeting of E.I.C. at Winnipeg, in May.

The Management Division of the American Society of Mechanical Engineers (ASME) has also expressed interest in the E.I.C. Division.

Management Training

Diploma courses in management are available for engineers at McGill and University of Toronto. The advantage of combining additional business training, in economics, business administration, and so on, with a conventional sound training in engineering should be apparent.

There has been an emergence, in recent years, of responsible business consultants operating on engineering and scientific principles.

Industrial engineering has also become a valuable practice for infusing new life into industrial operations, perhaps basically by instilling the principles of sound management. This may be done with the help of industrial engineering consultants, maintained by industrial engineering departments permanently incorporated into an industrial organization, or by individuals trained in the principles of good engineering and good management. Regarding this latter case, the need can be seen in many small companies, at a certain stage of their development, for men with such dual training.

Mechanical Engineering

THE progress of Canadian life and industry depends to such a large extent on technical developments in the field of mechanical engineering that it is not easy even to outline the major developments. However, in considering Canada's great size and huge natural resources, it is relatively simple to realize the need for transportation equipment, by air, land, and waterway; equipment to handle and produce the natural resources in the mines and forests; and the machinery and equipment throughout general industry that make the whole operation possible.

Aeronautical Engineering

The progress of aeronautical engineering in Canada from 1909 to 1959 is dealt with in the February 1959 issue of *The Engineering Journal*. During 1959 many *Beaver* and *Otter* aircraft, though products of an earlier stage in the Canadian aircraft industry, continued to give valuable service in remote and difficult areas. The *Caribou* transport was a relative newcomer, having first flown in July 1958. Production of the CL-44, the largest aircraft built in Canada, continued.

Automotive Industry

The automobile, truck, and bus industries involve little original Canadian design, but do require much mechanical engineering effort in planning and tooling for new models. A considerable alteration to equipment and procedures was necessitated by the introduction of the 'compact' cars.

Pulp and Paper

The pulp and paper industry in Canada has expanded its capacity considerably. During 1959 the industry was operated at not much more than 80% of capacity, and competition was severe. Much effort was made to combat difficulties and rising costs by improving the efficiency of cutting and handling pulpwood and of manufacturing processes in the mills.

The benefits of earlier work on the extension of wire life on paper-making machines was felt during the year. Some more recent research work showed the feasibility of moving wood chips in water through a pipeline over long distances.

The Canadian Pulp and Paper Association has been concerned with the cost of material handling within the industry. One project is the development of a special rail car for the shipment of pulpwood. Instead of conventional box cars, which have to be unloaded manually, an end-packed flat car could be loaded and unloaded by mechanical handling equipment. An investigation has shown reported estimated savings of 40% to 75% would be possible by using the proposed method over the present techniques.

Mining

The mineral industries have expanded at a very high rate in Canada during the post-war years. Though there was some reduction in this rate of expansion in 1959, the amount spent on capital and repair work in the mining and smelting industries is estimated at $549-million (compared with $570-million in 1958 and $681-million in 1957). The 1959 figure includes an estimated $106-million capital expenditure on machinery and equipment, and $112-million (approx.) repair expenditure.

As in the case of the pulp and paper industry, the year 1959 saw considerable activity towards the reduction of costs and improvements of efficiency.

There was a continuing trend, particularly in uranium mining, from trackless mining to slusher scraping in stopes and track haulage. On the other hand trackless mining was adopted by producers of rock salt and potash.

The largest capacity man cage in the uranium field was installed at Milliken Lake during 1959. This is a three-deck unit that can carry 86 men at one time. It is powered by one 1500-h.p. motor, is suspended by a 1¾ in. steel rope, and operates at a speed of 1800 f.p.m.

There has been a trend to new friction type hoist installations in Canadian mines. Canadian-designed disc air brakes have been introduced, which are said to give definite advantages over the old conventional parallel motion shoe types.

Attention has been paid to the efficient operation of heating and ventilating plants, with resultant savings in fuel and power costs.

One example of improvement in efficiency of above-ground haulage is seen in the use of two 40-ton payload road trucks for dry ore haulage. These trucks have aluminum-magnesium bodies which receive 40 tons of ore from a hopper and are discharged through air-operated gates.

Remote control of conveying systems, and automatic sampling of materials are further fields in which progress has been made.

Seaway and Power Projects

The many mechanical features of the various locks, dams, and other structures of the St. Lawrence Seaway — many of them designed specifically in Canada for the job — were tested thoroughly during the first season of operation. The St. Lawrence Power project was also in full operation.

Work continued on the expansion of the Richard L. Hearn steam plant in Toronto, to increase capacity from 400,000 to 1,200,000 kw., involving very large boiler and auxiliary installations. Also in the Toronto area is the new Lakeview station, which is to be among the largest thermal-electric plants in the world. A third thermal plant in Ontario is that at Thunder Bay, by Fort William, on which work progressed.

In addition to these and other thermal plants, the heavy fabricating industry was kept busy on water-power equipment for the many developments in the hydro-electric power field, of which some further details will be found in the separate report on that subject.

Projects posing some new problems to the engineer were the nuclear energy developments scheduled to be operating in the next few years. The two plants of immediate concern are the NPD (Nuclear Power Demonstration) unit of 20,000 kw. capacity on the Ottawa River, and the projected 200,000 kw. CANDU operational plant.

Special Vehicles

Much work has been done on the properties of muskeg, one of the major difficulties involved; and engineers have also been busy designing suitable vehicles for use on other types of rough terrain.

The Canadian-designed equipment ranges from six-passenger tracked personnel carriers, powered by a Volkswagen 30-h.p. industrial engine, to articulated tracked load carriers nearly 50 feet long, capable of carrying a 20-ton payload.

Industrial Developments

The transmission and distribution of petroleum and its products involves the use of a lot of mechanical equipment. Major pipelines operating in 1959 exceeded 20,000 miles in length, and Canada had the longest crude oil line and longest natural gas line in the world (respectively that of Interprovincial Pipe Line Co., 1930 miles, and of Trans-Canada Pipe Lines Limited, 2290 miles). These lines require large pumping or compressor capacity for their operation. Additions included 5000 h.p. on the Interprovincial system (in Canada) and 17,000 h.p. in four compressor stations of the Trans-Canada system.

Considerable interest was shown in the production of steel pipe for oil and gas lines, including the larger sizes (30 inches plus) formerly obtainable only from the U.S. or Europe. The major pipe manufacturers already established in Canada carried out programs of expansion, and two new manufacturing organizations had plants in course of construction during 1959 in western Canada.

A $12-million plant was opened in the summer in Montreal for the manufacture of steel wheels for railway use by a British-licensed process. The plant incorporates automatic control of many operating cycles and handling methods. The forging and rolling shop can produce 60 wrought steel wheels an hour, under controlled and recorded conditions, with the supervision of only seven operators.

Capacity for handling heavy machining operations was also increased during the year by the opening of a new machine shop at Trois Rivières, Quebec, by a major organization in the heavy fabricating field.

Bathurst's New 1250 P.S.I.G. Kraft Chemical Recovery Boiler and Back Pressure Turbine

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This paper will be presented at the Annual General Meeting of the Engineering Institute of Canada, Winnipeg, May 1960.

When Bathurst Power & Paper Company Limited of Bathurst, N.B. ordered their new kraft chemical recovery boiler to operate at 1250 p.s.i.g. and 850°F, there were none in existence operating at over 975 p.s.i.g. and 850°F. The 8750 kva Ljungstrom back pressure turbine which operates with this boiler was the first turbo-generator of this type over 1,000 kva ever installed in North America. This plant, which burns black liquor to recover the chemical from the kraft cooking process, has emphasis on the production of the most possible high pressure steam to produce cheap by-product power. The use of oil as a supplementary fuel has been used to allow more flexibility in burning liquor and also to keep the turbine operating at full load and best efficiency.

The Ljungstrom turbine, widely used in many parts of the world, has two complete sets of blading. One set, normally the fixed blading in other types of turbines, has a generator directly connected to it and rotates at a velocity equal in magnitude but opposite in direction to the other set which also is mechanically connected to a generator. The generators are electrically connected but mechanically free.

A PAPER MILL, of all industrial plants, probably has the best opportunity to produce cheap thermal power. This is due to the use of large quantities of process steam, which makes possible the production of a large block of what is commonly called by-product power or power made on back pressure turbines. This back pressure power is made by skimming off the top heat from the steam for conversion to power before going to process. The cost of this power for any steam condition, considering fuel cost only, is about 2 mills per kwh. Turbine efficiency, of course, is very high in this operation since the only losses are those from bearing friction and radiation, friction heat in the blading being passed on to process. About 3800 B.t.u are required to produce a kwh. Since the cost of most thermal power in the Maritimes for fuel only will be more than three times this amount, one can see the importance of making as much of this type of power as possible.

Uses of Steam

The Bathurst Power & Paper Company Limited mill at Bathurst, N.B. produces mostly chemical pulp. The plant contains a Groundwood mill which produces pulp by mechanical grinding of the wood but most of the pulp production is chemical, that is, cooking wood chips in digesters. These digesters, besides using chemicals, consume large quantities of steam at pressures of from 100 to 150 p.s.i.g. Hardwood is cooked by a semi-chemical process—a short cook and then mechanical defibration; softwood in an acid cook known as sulphite pulp, but the main use of softwood is to produce pulp in an alkali cook. This pulp is known as sulphate or kraft pulp. After the pulp is made, it is washed in vacuum washers, screened and refined. It then goes to the paper machines where the water it contains is first drained by gravity, then squeezed by presses, and finally dried by passing over steam cylinders which use large quantities of steam.

Recovery

In the sulphate process for the production of kraft pulp, large quantities of chemical are required. In order to make this process economical, the chemical must be recovered for use over again. After the chips are cooked the residual liquor, called black liquor, is drained off in the pulp washing process, while the pulp stock goes to the paper machine. The liquor is now ready to go through a process to reclaim the chemicals which it contains. Also, in this liquor are the wastes or wood fractions which are subject to solution under the cooking conditions. The heat value of this material is about 6300 B.t.u. per pound of dry solids. The first stage in the reclaiming process is to concentrate the liquor to about 50% dry solids in high vacuum evaporators. After further concentration in direct contact evaporators, it is then suitable for firing in a furnace where the wastes are burned off. The chemical is melted and runs out at the bottom of the furnace in the form of a red hot slag into a dissolving tank.

Early kraft mill recovery plants were designed chiefly as smelters to recover the chemical, the heat generated in burning the wastes being partly saved, sometimes by heating water. The first steam generating recovery boilers were also designed primarily for recovering the chemical. The quantity of steam generated was not as important as chemical recovery efficiency and operation. Modern recovery boilers are now being built to efficiently recover the chemical and at the same time efficiently use the available heat to produce high pressure steam for power generation.

New Recovery Boiler

In 1956 a decision was made to install a new recovery boiler to take the place of the old overloaded unit which generated about 35,000 lb. of steam per hr. at 175 p.s.i.g. At that time the steam generating plant consisted of two pulverized coal burning boilers operating at 625 p.s.i.g. and 715°F producing 110,000 and 175,000 lb. of steam per hr. and a bank of 175 p.s.i.g. boilers producing about

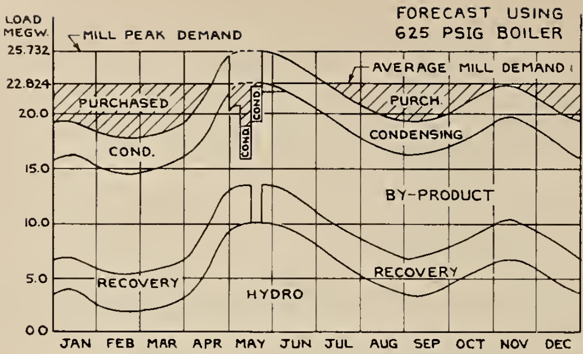


Fig. 1. Power productions forecast curves for 625 p.s.i.g. recovery boiler and turbine.

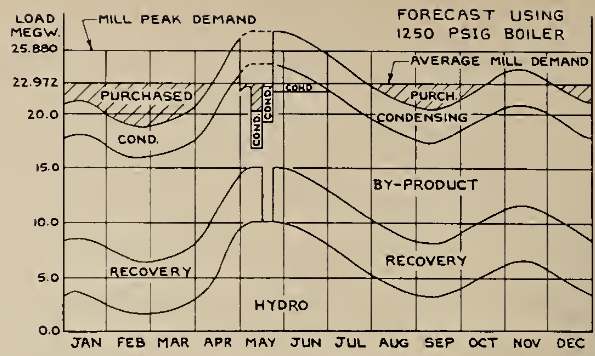


Fig. 2. Power productions forecast curves for 1250 p.s.i.g. recovery boiler and turbine.

80,000 lb. of steam per hr. with coal on underfed stokers. An old bank of Wicks boilers which produced 175 p.s.i.g. steam at about 60,000 lb. per hr. were to be removed to make room for the new recovery boiler installation. The above with the old recovery unit made up a total production of about 400,000 lb. of steam per hr.

The mill power requirements of about 22,000 kw. are met by three sources: thermal power from turbo-generators, with a total capacity of 23,000 kw., 11,000 kw. from the company's hydro plant which has no storage, and a 10,000 kw. transformer tying the plant to the New Brunswick Electric Power Commission network.

The paper machine dryers and all low temperature process work use steam from the 48 p.s.i.g. header which is supplied by back pressure and bleed turbo-generators. Steam at 165 p.s.i.g. is used for the cooking of chips in the digesters and also to run the steam engines driving the paper machines. These engines exhaust into the paper machine dryers at about 36 p.s.i.g. Some of the 165 p.s.i.g. steam is produced on the low pressure boilers but most is exhaust or bleed from turbo-generators.

When the order was placed for the new recovery boiler to operate at 1250 p.s.i.g. and 850°F, there was nobody in America operating a unit burning this fuel above 800 p.s.i.g. and 750°F. In Finland a unit was operating at 975 p.s.i.g. and 850°F. The decision to use these conditions came after making a thorough investigation of the various pressures and temperatures up to 1500 lb. and 900°F. The simplest installation would have been 625 p.s.i.g. and 715°F since it would have tied in directly with the other high pressure boilers. There was no reason why a recovery boiler could not be constructed to operate at high pressures similar to boilers burning other fuels but there was a limit on temperature. There would be quite an advantage in operating at the usual temperature for this pressure of 1000°F but due to the danger and trouble caused by chemical attack and slag adhesion on the superheater tubes, 900°F was considered the limit. At this temperature the whole superheater would have to be stainless steel.

Economy studies were made in which the yield from the additional power available from the higher pressures was balanced against the increased capital cost. The total annual saving from this boiler and turbine is produced from two sources: first, by the saving in coal by producing a greater quantity of steam from the black liquor burned, and second, by the additional quantity of cheap power produced. The old recovery boiler was greatly overloaded and was working more as a smelter. It was working at very low efficiency and producing about half as much steam as should be available from the black liquor. Also, this boiler did not produce by-product power, being one of the first steam generating recovery units in the industry, built by Babcock-Wilcox & Goldie-McCulloch Limited and installed in 1939 to produce 175 p.s.i.g. steam for process. The saving from by-product power produced on the new boiler and turbine is about equal to the saving from burning liquor instead of coal. Thus, one can appreciate the importance now attached to the production of power on this recovery boiler. This boiler then has three important jobs to do: first, recover chemical for the kraft cooking process, second, produce steam from the heat available in the liquor and save coal fuel and third, produce steam at conditions which will allow the greatest return from the production of by-product power.

To make a study, future mill electrical loads had to be estimated and since power produced depends largely on the amount of process steam used, the demand for steam at the various pressures also had to be closely studied and estimated for the future. Many electrical and steam load balances had to be made since the generation would be on three back pressure units which share the load differently, depending on the electrical and steam demands. An example of one of these steam and load balances is shown in Fig. 3. Curves shown in Fig. 1 and 2 are a sample of those used to anticipate the purchased power saved by the increased generation from the new back pressure turbine. The bottom curve shows the average power from the hydro plant. The next block of power is that available from the new recovery boiler and back pressure turbine. Next to this is the block of power from the 625 lb. steam turbines as by-product power. On top of this is a block of power made by one turbine by steam exhausting into a condenser. The level line is the mill load and the block of power between the top curve and the load line is the amount of power required to be purchased from the New Brunswick Electric Power Commission. The savings available from the increase in production by higher pressure steam is the difference between the low cost by-product power and the power purchased from the New Brunswick Electric Power Commission.

The mill power contract with the Commission is one in which either party will help the other when power is available and there is no firm contract. Although this arrangement has worked exceptionally well, it is an advantage to make more power so as to be as independent as possible. The difference in power production between the steam conditions of 625/715 and 1250/850 worked out to be 1500 kw. at the estimated operating conditions.

The percentage yield from the total savings from fuel and power for a 625 lb. installation is about the same as for a 1250/850 installation but the additional yield from the higher pressure gave a very good return on the additional capital cost. With 850°F steam about half the superheater had to be stainless steel and a change to 900°F required additional stainless steel at a cost of about $50,000. The yield from the additional superheater was only about $6,000 so that this would not be an economical choice.

Increasing the pressure to 1500 p.s.i.g. at 850°F decreased the steam volume to such an extent that the turbine blading became too short in the high pressure stages and efficiency was reduced so that only about half the extra available heat would be available in power. To get good turbine efficiency at 1500 p.s.i.g. the temperature would have to be increased to at least 900°F. The yield by increasing from 1250/850 to 1500/900 was only about 5% after paying taxes. Considering the low return and the fact that there was a good possibility of excessive superheater maintenance at this temperature, there was no difficulty in deciding against these conditions.

The design, investigation, and specifications on this job, as on all of our projects, was done by our Engineering Department. The boiler was purchased without auxiliaries such as fans, pumps, instrumentation, heaters, water treatment, etc. Actually, the whole boiler was not purchased from the boiler manufacturer as it was also purchased without the supporting steel.

Method of Firing

The kraft liquor comes from the evaporators at a temperature of about 180°F and contains about 50% solids and 50% water. It looks similar to tar although at this temperature it is similar to water in viscosity. Before going to the furnace it is passed through a direct contact evaporator in the boiler flue gas after it leaves the air heater where the water is reduced to 36% and the solids raised to 64%. The liquor is then pumped to a saltcake mixing tank where the chemical make-up is added to the system. Some of the sodium chemical which is used to cook the chips is lost in washing the chemical from the pulp and also in the form of dust up the stack. To make up for the losses, saltcake is added to the liquor before firing. From the mixing tank the liquor is pumped directly to the burner which is a spray type oscillating nozzle mounted on the front wall of the furnace. The furnace is similar to that used for oil or pulverized coal only it is considerably larger. The liquor is sprayed back and forth and dries on the furnace wall, then falls to the bottom of the furnace where a pile of dried solids forms and burns. The resulting smelt runs out of two spouts at the low side of the sloping bottom into a tank where it is dissolved in weak wash to be pumped to the caustic plant for processing.

For starting, temporary oil burners may be inserted in the secondary air ports that are located on the furnace periphery about seven feet above the bottom of the furnace. Five burners may be used for this purpose and one or more of these may be required to heat up the furnace until ignition of the wet fuel will take place.

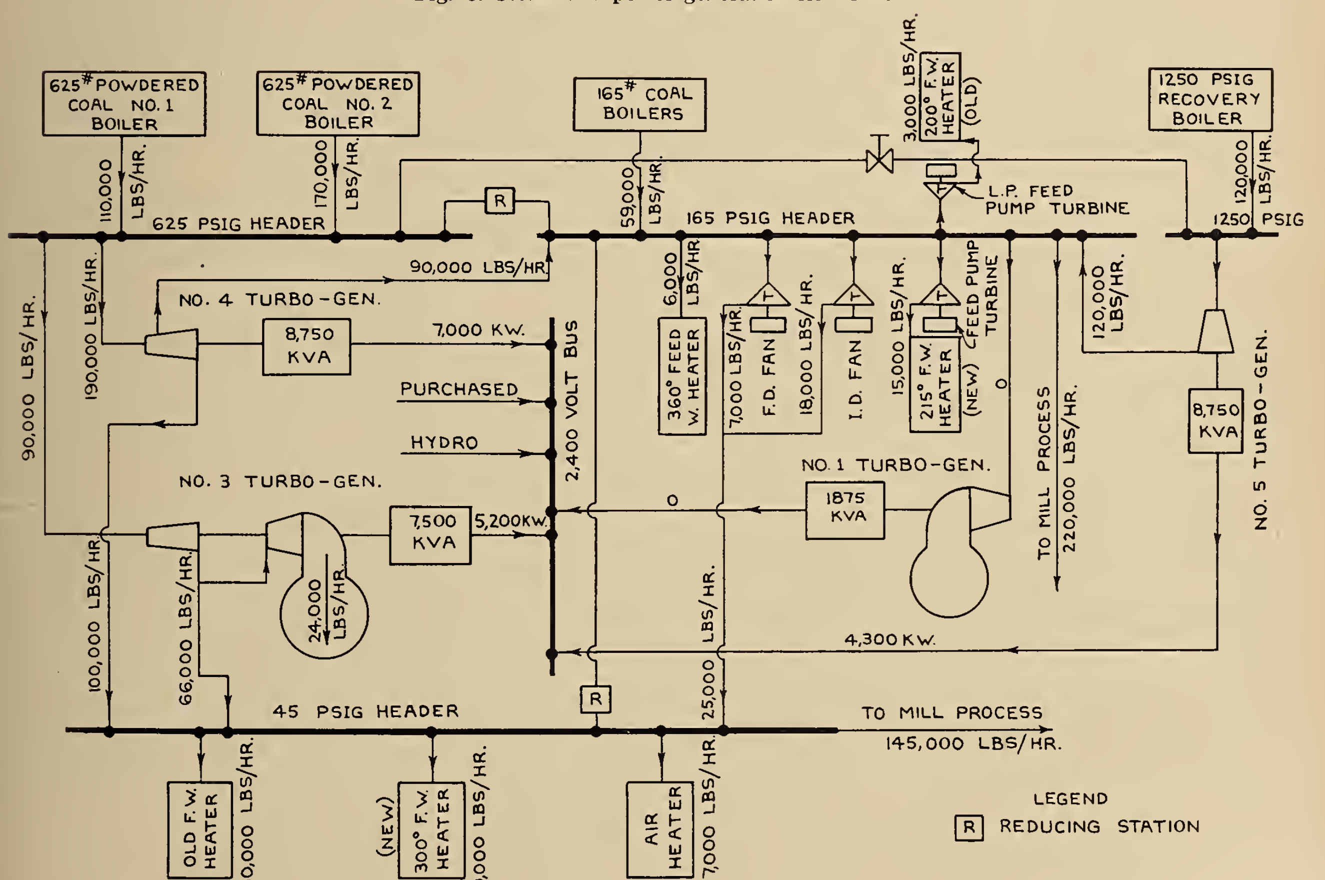
Chemical Recovery for Flue Gas

During the combustion process considerable chemical is carried up the stack and, in a plant of this size, the annual loss can be well over $100,000. There are two methods of recovering this chemical.

One method which has been quite common on recovery boilers is to pass the flue gas through a cascade evaporator, a tank with paddle wheels revolving in liquor so that the liquor is carried up on the paddles and is exposed to the hot gases, then passing the gas through electrostatic precipitators. The gas is kept above 300°F leaving the evaporator so as to keep the gas dry and above the dew point of sulphuric acid in the precipitators.

The other method, and the one

Fig. 3. Steam and power generation flow sheet.



which was selected, is to pass the gas through a venturi evaporator scrubber and a cyclone separator. This is a system developed by Babcock-Wilcox & Goldie-McCulloch Limited for use on their recovery boilers. Bathurst had installed the second venturi scrubber in existence on the old recovery boiler in 1948. This system consists of a venturi section in the boiler outlet duct through which the gases travel at about 250 f.p.s. with a pressure drop of 25 in.-35 in. of water. At the point of highest velocity black liquor is sprayed in through several nozzles. The very high velocity breaks down the liquor into a very fine mist wetting down the chemical dust particles. The gas is then passed tangently into a cyclone tank where the liquor containing the chemical dust is separated, the gas passing out the top to the induced draft fan and the liquor running down the walls of the tank. A pump circulates the liquor from this tank back to the venturi and also to a group of showers at the top of the tank that are used to continuously wash down the tank walls. As the liquor circulates around from the venturi to the tank in the hot gases, water is evaporated until the liquor is at the desired consistency for burning. Liquor for burning is bled off from the circulating pump to the saltcake tank and then to the furnace. This system will average about 90% efficiency in removing the chemical from the flue gases.

The total draft loss through this system is 30 in.-40 in. and the power consumed by the induced draft fans is considerably more than for the first method, but the lower stack gas temperature of about 180°F to 200°F gives an additional 6300 lb. of steam per hr. from the boiler at full capacity. The value of this additional steam and its by-product power is more than enough to pay for the cost of the greater power use by the fans. Although the peak efficiency of the precipitator is slightly higher than the venturi scrubber, for this investigation we estimated the average annual efficiency to be equal. We also estimated the cost of the precipitator installation to be over $100,000 more than the scrubber and the maintenance to be higher also. Even at the high power cost in this area the study showed the venturi to have a considerable saving over the precipitator.

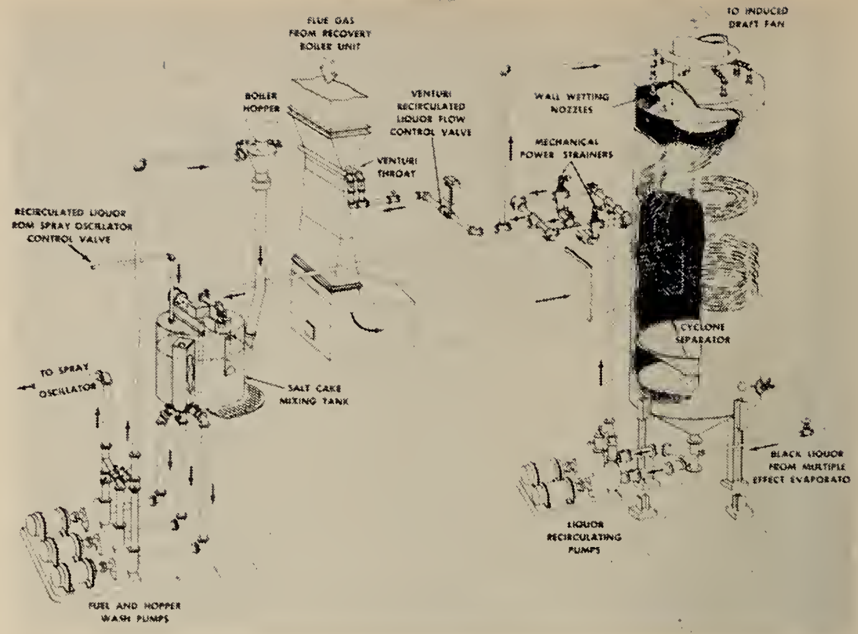


Fig. 4. Venturi scrubber evaporator and cyclone separator.

Boiler Capacity and Supplementary Fuel

It has been the usual practice to rate a kraft recovery boiler in tons, meaning that it is capable of handling the black liquor resulting from so many tons per day of kraft pulp production. This rating actually does not tell much since the amount of heat available from different kraft processes is not the same for all mills. It is generally considered that a ton of production gives 3,000 lb. of solids for burning, but Bathurst's process yields considerably less per ton of kraft production.

Sizing a recovery boiler is perhaps not as simple as sizing a power boiler. First, it is necessary to decide what capacity is required to look after the Kraft mill without adding another unit until this one is worn out, or for at least another 25 years. Normally, a recovery boiler capacity is not very flexible. Due to the wet fuel, ignition will fail unless the furnace is working at about 60% of designed capacity and good operation can be expected up to 20% overload. At normal full load, efficiency is about 64% (based on dry fuel).

For 10% under rating, efficiency is about the same with a drop to about 62% at 20% under rating. At 15% overload, efficiency will drop to about 63% and at 20% overload it is down to 62%. Over 20% overload efficiency falls off rapidly and plugging between the tubes can give a lot of trouble although some boilers have been operated at very high overloads.

Thus, in using one unit, if the above conditions are to be satisfied, it is important to know what the kraft production will be in the future. Many things can change the kraft production; changes in the types of paper board may change the demand or the type of cook required may change the amount of solids available per ton of pulp.

Since the boiler was also to be operated as a power boiler, making cheap by-product power on its own turbine, it would be important to operate it within rather narrow limits in order to get the best efficiency and make it easier to size the turbine. This is believed to be the first recovery boiler in existence operating its own turbine. Other recovery boilers supply steam for power production through a common header with other coal or oil burning boilers.

Although recovery boilers had not been used to burn other fuel with the liquor except for start-up, the solution to most of the above problems in sizing could be solved by burning oil as a supplementary fuel. Burning oil with liquor was considered possible and practical within limits. Furnace temperatures would be increased but this was not expected to cause any trouble as long as the quantity of steam from oil was not much over an estimated 30% of the boiler rating.

With a supplementary fuel there would be no concern with the boiler being slightly large for periods of low production. The oil fire would eliminate the danger of fire failure at low loads. The boiler was therefore sized for our estimated greatest future requirements when running at 20% overload. At full load, designed capacity is 30,625 lb. of black liquor per hr. to produce 123,800 lb. of steam per hr. Two oil burners with a maximum capacity of 40,000 lb. of steam per hr. were installed above the liquor burners to operate only when insufficient liquor is available for full load. Continuous use of the lower start-up burners is not recommended due to their location close to the ash bed and the bottom of the furnace.

In sizing the turbine to take the steam from this boiler, it is quite important, especially with a reaction type turbine, to run it at rated capacity, which is also peak efficiency. Since the quantity of steam produced from liquor may vary considerably the turbine would operate much of the time at reduced efficiency. With a supplementary fuel the turbine could be designed to operate at 120,000 lb. of steam per hr. and run continuously at this load. Liquor might produce only 90,000 lb. of steam per hr. but the oil burners could automatically keep the steam flow at 120,000 lb. per hr.

In sizing the unit, it was necessary to decide on the advantages of one new large unit as against using the old low pressure boiler, which was only 17 years old, and a smaller high pressure unit. The advantages of the large unit were quite obvious and the study showed the one large unit to give an annual saving of about $250,000 over the two units.

Although the cost of oil at present prices (bought in tank cars) is higher than coal, the extra steam made by oil gives a good yield because of the larger amount of by-product power available from the 1225 p.s.i.g. turbine.

Maximum Amount of 1225 p.s.i.g. Steam

Due to the fact that cheap power from hydro is not available in the Maritimes, it is very important to produce as much by-product power as possible. For this reason, every effort has been made to produce the maximum amount of steam from this 1250 lb. unit. The other high pressure boilers use feed water at 295°F but in this one the temperature was increased to 360°F by heating in a closed heater with 165 p.s.i.g. steam. Air enters the air heater at 250°F after being heated with 45 p.s.i.g. steam in a steam coil air heater and enters the combustion chamber at 370°F. This, of course, does not increase the mill steam supply but it does make more by-product power by circulating more heat through the turbine and back to the boiler. The boiler was originally quoted on a design using liquor at 57% solids but greater heating surface was added to the economizer and air heater so that liquor could be fired at 64% solids. It is much more efficient to evaporate water in high vacuum evaporators where several pounds of water can be evaporateed with one pound of steam than to evaporate in the furnace at atmospheric pressure. With the changes made in this unit it now produces more heat in the form of steam from a pound of black liquor solids than any other unit in existence.

Drives for Auxiliaries

There is perhaps a tendency sometimes to overlook some of the advantages in using turbine rather than electric drives for auxiliaries. If a plant is purchasing high cost power such as is produced by a condensing plant and is using low pressure process steam, then the small turbine drives offer an opportunity to make some cheap by-product power for pumps or fans. The fact that pumps and fans can be run slower to effect control with a considerable power saving than to waste power in throttle valves or dampers is very generally accepted. There is another good reason for using turbines on auxiliaries in power plants or mills where the exhaust steam can be used for process, and this also applies to plants generating their own by-product electric power. Every electric motor has to be backed up with a turbo-generator which costs about four times the cost of the motor per horsepower. The capital tied up in a 500 hp. motor drive may be about $50,000. The same size turbine will cost about $5,000 and when piping is added the motor installation is still probably five times as much. The large turbine will have a slightly better efficiency than the small one, but with the motor drive we have the electric losses in both the motor and the generator which are more than enough to make up for the difference in the turbine efficiencies.

The main turbo-generators exhaust into the 165 p.s.i.g. and 48 p.s.i.g. headers. By installing two open heaters, one to operate at 2 p.s.i.g. and one at 45 p.s.i.g., an opportunity is provided to exhaust one 500 hp. turbine at 2 p.s.i.g. and thereby gain a little more by-product power.

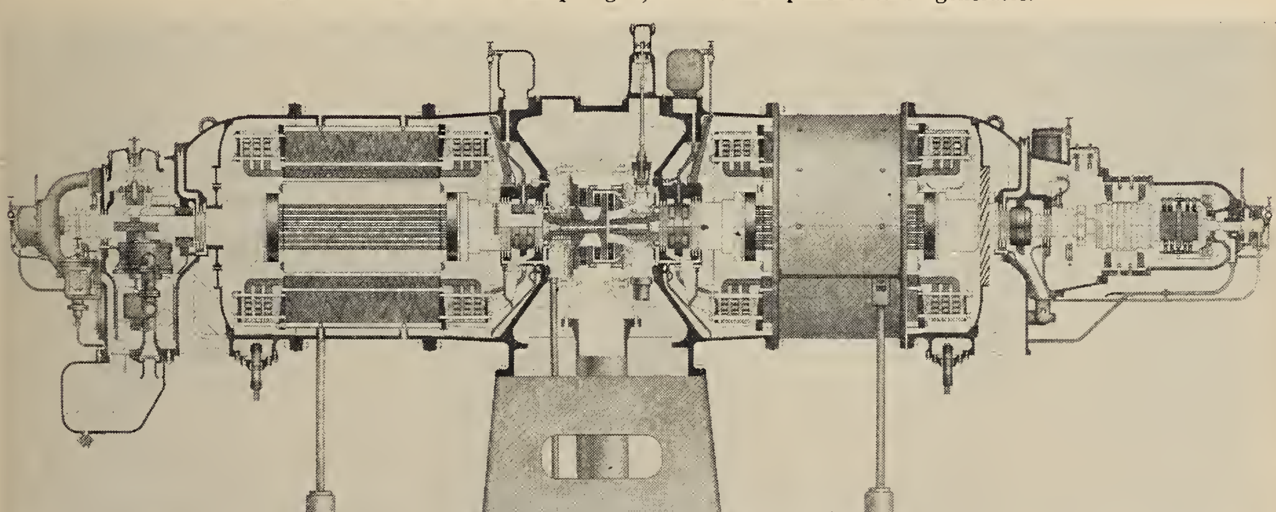
Boiler

The two drum 16 ft. 9 in. wide boiler has a height of 95 ft. and a furnace volume of 14,020 cu. ft. Heating surfaces are 4.070 sq. ft. in the furnace, 16,357 for the boiler, 10,280 in the economizer and 10,600 for the gas air heater. The superheater is a pendant two stage type with a heating surface of 7,928 sq. ft. and having about half of the tubes made of stainless steel. This boiler is comparable in size to that of a boiler operating on coal with a steam capacity of about 300,000 lb. per hr.

Boiler Cleaning

The main body of the boiler is cleaned by 13 retractable automatic

Fig. 5. Sectional view of 1225 p.s.i.g. 7,500 kw. back pressure turbo-generator.



sequential soot blowers operating with up to 300 p.s.i.g. steam from the 625 lb. system. The economizer and air heater are cleaned by a shot cleaning system in which a batch of steel shot, ¼" x ¼" punchings, is carried by air to the top and falls down through the units. The system is automatic and the intervals of operation can be set at the control panel. The system is run by compressed air at 150 p.s.i. but to cut down on the size of compressor and storage the air is compressed to 300 p.s.i.g.

Feed Water Heaters

Feed water is supplied from the water treatment plant to the 2 p.s.i.g. open heater which has a storage of about ten minutes at full capacity. Steam is supplied from the boiler feed pump drive turbine exhaust and a reducing valve from the 48 p.s.i.g. header.

Deaerating of feed water is done in the 48 p.s.i.g. heater which raises the water temperature to 295°F before entering the feed pump. This heater has a storage of about two minutes at full capacity.

The closed heater is located in the feed pump line and operates at 165 p.s.i.g. steam pressure to deliver 360°F water to the economizers. Economizer outlet temperature is 475°F.

Boiler Feed Pumps

Two single casing, 12 stage, centrifugal boiler feed pumps, rated at 180,000 lb. of water per hr. at 3800 ft. head or 1,525 p.s.i.g. running at 3600 r.p.m. are used. One, driven by a 535 hp. steam turbine, will be used normally and one with an induction motor is used as a spare. The turbine takes steam at 160 p.s.i.g. and exhausts at 2 p.s.i.g. When the turbine is used, the feed water level control adjusts the turbine speed to keep the pressure across the feed water control valve at 75 p.s.i.g. Feed water is automatically bled back to the heater if the feed water flow goes below 50 g.p.m.

There has been a definite swing to double casing boiler feed pumps today. This is certainly justified when the boiler operating pressures get above 1500 or 1800 p.s.i.g. but, in the writer's opinion, for the 900 to 1400 p.s.i.g. plants it is a waste of money to use these pumps. Not only is the cost of the pump double, but when the pump has to be worked on, the maintenance cost is much higher also. Apparently some of the manufacturers discontinued this line of boiler feed single casing pumps for 1200 to 1800 p.s.i.g. rating after they started making the double casing pumps and are now recommending double casing pumps for all plants above 1000 p.s.i.g. This is especially bad for the smaller installations where the cost of feed pumps is a rather large part of the cost.

Fans

The forced draft fan has a capacity of 55,000 c.f.m. at 15 in. H_2O and is driven by a 175 hp. turbine with a 4500/1245 r.p.m. reduction gear. Turbine speed is controlled automatically by the air requirements of the boiler. This turbine is designed to take steam at 160 p.s.i.g. and exhaust at 45 p.s.i.g. but the exhaust is also piped to go to the 2 p.s.i.g. heater, if desired.

The induced draft fan requirements on a recovery boiler equipped with a venturi scrubber are unusually high compared to most boilers. Two fans running at 1170 r.p.m. with a combined capacity of 91,000 c.f.m. at 48.1 in. of water operating at 200°F are connected in series. One is driven by a 470 hp. turbine with a 4500/1150 r.p.m. reduction gear taking steam at 160 p.s.i.g. and exhausting at 45 p.s.i.g. and the other by a 500 hp. induction motor. This electric motor driven fan is operated with a slight amount of throttling and the draft is controlled by first opening or closing the damper for quick response and then changing the speed of the turbine. This is done automatically by the combustion controls.

For simplicity and economy a single fan arrangement was at first much preferred. There was considerable resistance to this on the part of some of the fan manufacturers due to the high peripheral speed of about 31,000 f.p.m. for the fan wheel. The fan wheel was specified to be type 316 stainless steel in order to combat corrosion. This material does not stand up well under fatigue and the manufacturers were afraid of failure due to a calculated periphery stress of 23,000 p.s.i. Some of the manufacturers did agree to build a single large fan, but on further study it was decided that because of the high stress and also because there was a spare 400 hp. motor from the old venturi fan available, the double installation was selected. The boiler can be run at part load with one fan. Due to the high cost of stainless steel in the large fan casings, only the wheels and the entrance cones to the wheels were made of stainless steel. The remainder of the fans was made of ½ in. thick cor-ten steel.

Stack

From the first, it was planned to use a steel stack supported on the roof and the building steel was designed to carry a 75 ft. high, 5 ft. dia. stack made of ½ in. mild steel. As the job progressed and more thought was given to the stack and its erection, it was found that a light weight stainless steel stack would save considerably in erection cost and then there would be no concern about corrosion. The height was needed to carry the wet chemical fumes away from a brick stack which was close to the new stack. Finally, since the brick stack would be taken down in a few years and 25 ft. would have to be taken off the top immediately, it was decided to reduce the height of the stainless steel stack to 40 ft. A stainless steel stack, with the bottom half of 3/16 in. and top half of ⅛ in. material, was purchased. It was erected by clamping a mild steel frame to the bottom of the stack and connecting it to the portion through the roof with a pin hinge. Chain blocks were fastened to the top of the steel frame and the frame pulled down so as to tip the stack up into place. The hinge and framework were then removed.

Piping

All plant piping was designed by the company's Engineering Department including the main 8 in. steam line to the turbine. The main steam pipe and header were fabricated in Montreal and shipped to Bathurst in large sections. Erection of this pipe was contracted to an outside firm since the company did not have the necessary stress relieving equipment nor welders experienced in welding this material.

Liquor Pumps

Probably the only difficult pumping job of special interest is the pump taking the heavy liquor from the cyclone evaporator tank and pumping to the venturi scrubber and showers. This pump has a capacity of 1550 U.S.G.P.M. at 124 ft. head with liquor at 65% solids and is driven by a 200 hp. motor.

The heavy liquor gives difficult suction conditions and on similar installations in the past it was considered that only a 1200 r.p.m. pump could be used. It was found that of the pumps available, a more efficient selection could be made with a 1750 r.p.m. pump. Seeing that with the proper suction conditions there was no reason why the higher speed pump would not perform just as well, it was selected for continuous use and a slow speed pump, as recommended by the boiler manufacturers, was selected for a spare. Since starting up, the high speed pump has been preferred by the operators.

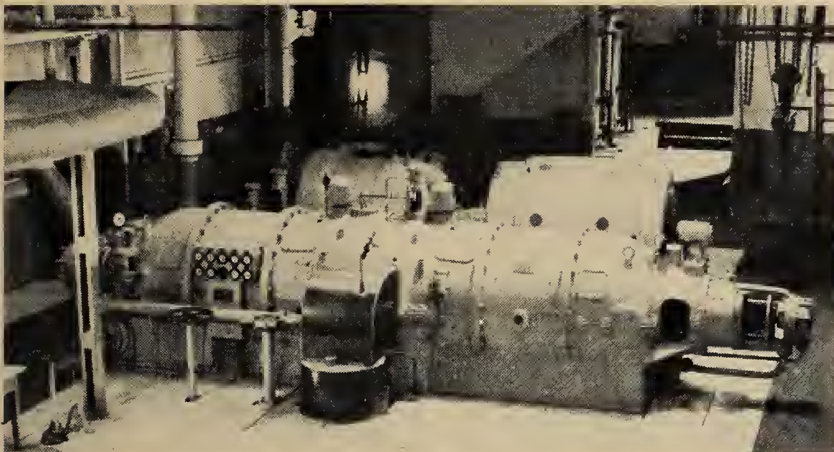


Fig. 6. New 1225 p.s.i.g. 7,500 kw. back pressure turbo-generator installed in turbine room.

Instrumentation

The instrumentation on this boiler is probably more extensive than is usual for boilers of this type. As a result, the boiler can normally run on automatic control with only occasional adjustments being made by the operators. Also, the normal complement of four operators has been cut to two. Further, the precise control afforded by a properly designed instrumentation program allows the boiler operators to more closely approach the efficiency inherent in the recovery plant.

Some of the control features include:

(a) Three-element drum level control which also controls feed water flow;
(b) Feed water pressure and pH control;
(c) Steam pressure and temperature control;
(d) Oil and black liquor flow control;
(e) Air fuel ratio control;
(f) Excess air control;
(g) Fuel temperature control;
(h) Black liquor density control;
(i) Draft control;
(j) Strategic furnace gas differential indication;
(k) Strategic water, steam, gas and air temperature indicators. Some of the more important are recorded and/or tied to an alarm system;
(l) Tank level control and indication;
(m) Integration of water, steam and black liquor flow;
(n) Remote controls allowing the operator to completely control the boiler from the control panel.

Water Treatment

Since so much of the steam is used in process for cooking and direct heating, approximately 50% raw water make-up is required for the boilers. With this large amount of make-up, the present internal boiler water treatment on the 625 lb. boilers was not considered satisfactory and some improvement was preferred if additional high pressure boilers were to be added.

With the 1250 p.s.i.g. boiler it is essential that pure water is provided and this required the installation of a raw water clarifier, filters, and a complete demineralizing system. Effluent contains less than 1 p.p.m. dissolved solids and less than 0.02 p.p.m. dissolved silica.

Some of the condensate returns would be clean but there was a chance that some pollution could occur. It was therefore decided to return all condensate to the 625 p.s.i.g. boilers and to install a mineral exchange plant to use all raw treated water for the new boiler. This water plant was installed with an initial capacity of 300 U.S.G.P.M. but it was designed so that its capacity can be inexpensively doubled.

Semi-automatic equipment was installed to control flow, chemical feed and demineralizer regeneration. Chemicals used are alum, sodium aluminate, sulphuric acid and caustic soda.

Economizer on Dissolving Tank

There is a considerable amount of heat liberated in the dissolving tank from the chemical smelt. Also, steam showers are used to break up the streams of smelt to reduce the noise caused by the smelt entering the water. This tank is normally vented to atmosphere through the roof. To save a large part of this heat, an economizer system was installed to use this waste heat to heat air for the furnace from zero in winter up to 150°F before entering the steam coil air heater.

Oil Supply

For the present, oil is purchased by rail in tank cars and only a small storage tank of about 40,000 gal. is used. Winter harbour facilities are not available due to ice, so purchasing cheaper oil by tankers would require large storage facilities. These will be considered at a later date if considered economical.

625 lb. Operations

The recovery boiler, as part of the kraft pulp process, must run when the pulp mill runs. Normally, the 1250 p.s.i.g. steam is reduced to process 165 p.s.i.g. steam through the turbine. If anything should happen to the turbine or if it were down for overhaul, the liquor must be burned and the boiler kept operating with a method of using the process steam.

Instead of installing a reducing station between the 1250 lb. and 625 lb. heaters, only a stop valve was installed. The boiler has been designed with additional circulating rises to operate properly at both 1250 and 625 lb. and if the turbine is down, the boiler will be operated with the steam going into the 625 lb. header. Actually, the boiler is started up by feeding steam to this header. After the turbine has been started on 625 lb. steam, the stop valve is closed and the pressure then is raised to 1250 lb.

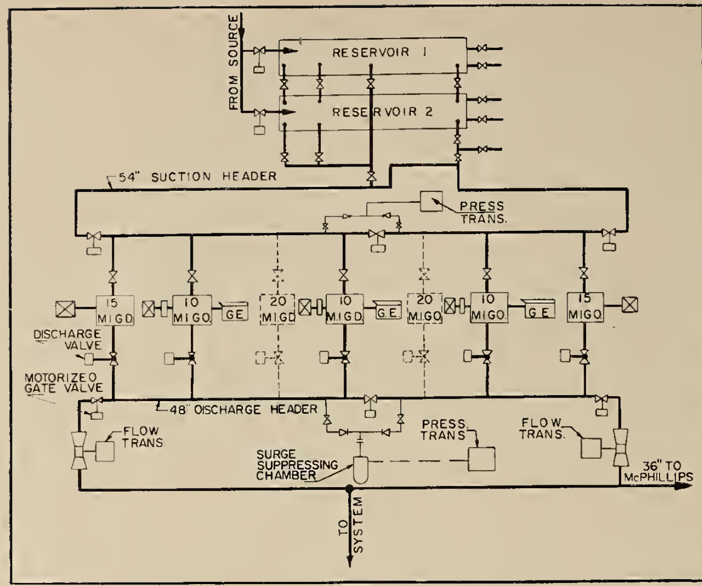
Turbine

For some time we had been interested in the radial flow, double rotation type of turbine. This turbine was invented in 1912 by Birger and Fredrik Ljungstrom of Sweden. It has not been too well known in North America but has had considerable success in all other countries of the world.

The design is a radical departure from the conventional turbine in that it has no stationary blading. It is a reaction turbine with the blading mounted on two wheels turning in opposite directions. Steam enters at the center of the wheels around the shaft and expands radially through the blades towards the circumference. Small size is possible due to the high relative velocity of the blading travelling in opposite directions, and narrow blades of the small unit tend to give somewhat better efficiency.

The turbine in the Bathurst unit is especially small due to the high inlet and exhaust pressure. The water rate on this unit is 7% lower than that of the nearest competitor from which quotations had been obtained. This small turbine, having a blading assembly measuring only 15 in. long and 20 in. diameter, can develop 12,000 hp. and is probably the most powerful engine in existence for its size.

(Continued on page 102)



SUPERVISORY AND AUTOMATIC CONTROL SYSTEM FOR WINNIPEG UNATTENDED PUMPING STATION

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This paper will be presented at the Annual General Meeting of the Engineering Institute of Canada, Winnipeg, May 1960.

THE CITIES of Winnipeg and St. Boniface and the suburban municipalities by the incorporation of the Greater Winnipeg Water District in 1913, commenced the development of a permanent water supply system with construction of an aqueduct to bring a supply of clear, pure, medium-soft water from an arm of the Lake of the Woods known as Shoal Lake, 97 miles east of the metropolitan area.

Shoal Lake is some 290 ft. higher than prairie elevation at Winnipeg, and advantage was taken of this fact to deliver water under open flow conditions through a horseshoe shaped conduit of plain concrete varying in dimension from 10 ft. 9 in. x 9 ft. 0 in. to 6 ft. 4¾ in. x 5 ft. 4¾ in. for some 80 miles. From the west end of the horseshoe section there is a depressed section of reinforced concrete pressure pipe 8 ft. in diam., 4 miles long to a reservoir site at Deacon (Mile 13).

From Deacon (Mile 13) to St. Boniface (Mile 5) a 5 ft. 6 in. diam. reinforced concrete pressure pipe carries the water to a surge tank on the eastern bank of the Red River. The water then passes into a 5 ft. diam. cast iron pipe in tunnel under the Red River, and thence through a 4 ft. diam. reinforced concrete pipe through the streets of Winnipeg to an 18 million gal. covered concrete reservoir (McPhillips Street Reservoir) in the north-western part of the City (Mile 0). The 5 ft. 6 in. reinforced concrete pipe was provided with 36 in. off takes at Transcona and St. Boniface where these cities maintain pumping equipment to pump directly from the aqueduct into their respective distribution systems.

When the supply came into service in March, 1919, St. Boniface was required to pump water to the Municipality of St. Vital and to supply itself while Winnipeg was required to undertake the supply of all the other municipalities except the Town of Transcona.

The maximum capacity of the aqueduct between Shoal Lake and Deacon was 85 million imperial gallons per day, but the capacity of the pressure section between Deacon and the McPhillips Street Reservoir was only about 35 million imperial gallons per day when the demand to both Transcona and St. Boniface was high.

In 1929-1931 the City of Winnipeg constructed a 50 m.i.g.d. pumping station (since increased to 67 m.i.g.d.) and a 40 m.i.g. reservoir of the open concrete lined earth embankment type at McPhillips Street immediately adjacent to the 18 m.i.g. existing covered concrete reservoir. Fears were expressed at the time as to the wisdom of operating an open reservoir in the City considering the possibility of pollution, the development of algal growths, and damage to the reservoir itself by soil action and prolonged periods of sub-zero temperatures. These fears have proven to be groundless except for one period of severe algal growth and resultant taste and odour troubles (since overcome by the continuous feeding of copper sulphate during the summer season at the intake and the use of breakpoint chlorination).

The system described above remained from 1919-1950 almost without change but in 1949, owing to the substantial post war growth of the Winnipeg area, it became difficult to deliver sufficient water to the McPhillips Street Reservoir by gravity.

The Greater Winnipeg Water District, in 1950, built a 40 m.i.g.d. booster pumping station in St. Boniface which pumped water from the surge tank across the Red River to McPhillips Street thus making available at the McPhillips Street reservoir a supply of 38 m.i.g.d. using 2—20 m.i.g.d pumps or 42 m.i.g.d. using 3—20 m.i.g.d. pumps. With the installation of this station the District could fully develop the capacity of the 5 ft. 6 in. line to 50 m.i.g.d.

Major Improvement Programme

It soon became apparent, however, that this was a stop-gap measure and therefore the City of Winnipeg and the Greater Winnipeg Water District became jointly engaged in the first major expansion of their water works facilities in the past 40 years.

The engineering staffs of the Greater Winnipeg Water District and the City's engineering department, in 1952, made a joint study of the problem and as a result the City Engineer recommended to the City Council that—

1. New pumping and storage facilities be established near the south-western boundary of the City;
2. A 36 in. diam. tie feeder main be constructed to join the McPhillips Street Pumping Station on the north-western edge of the City with the new reservoir and pumping station to be established near the south-western boundary;
3. A 5 yr. programme of distribution main improvements be undertaken;
4. The proposed programme be undertaken on the condition that when the new reservoir and pumping station is constructed by the City the Water District provide the second branch aqueduct line to feed the new facilities.

The joint committee believed that the new reservoir, pumping station and branch aqueduct would be required some time between 1960 and 1965 and that the reservoir should have a capacity of 80 million gal. to provide a two day supply of water in the event of a failure occurring on the aqueduct east of Deacon.

The recommendations of the City Engineer were accepted and the City commenced the programme by construction of enlarged distribution mains.

In 1956, it became apparent, because of rapid population growth, that the cross-town tie feedermain would have to be commenced immediately to be followed by the construction of the new 80 million gal. reservoir, pumping station and branch aqueduct. The Greater Winnipeg Water District then undertook the preparation of plans for a 66 in. pressure pipe line from Deacon (Mile 13) to the proposed Wilkes Avenue reservoir in south-west Winnipeg. In addition the District came to the conclusion that it would have to take measures to ensure that 85 m.i.g.d. could be introduced into the aqueduct at the intake under any possible low lake levels. Studies were undertaken to determine whether this might best be accomplished by the construction of a dam at the entrance to Shoal Lake, or by the construction of a pumping station at the intake. The Districts' engineers ultimately recommended construction of the low life pumping station at the intake.

Construction of New Works

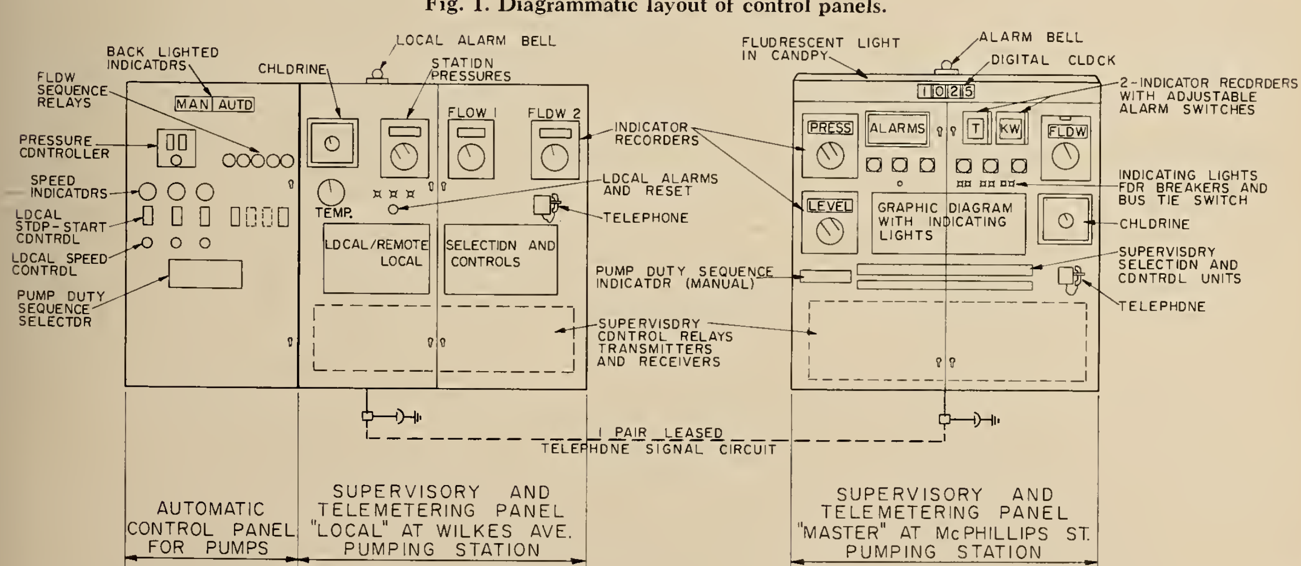
Construction began in 1956 with the installation of the 36 in. cross-town feeder main. In 1959 construction commenced on the branch aqueduct line, the low lift station and intake at Shoal Lake and the new reservoir and pumping station in south-west Winnipeg.

The details of the work carried out by the City of Winnipeg follow:

(a) *Balancing (or tie) Main:* The 36 in. balancing main (fully constructed) will act primarily as a feeder main in the Winnipeg distribution system, but is designed so that in an emergency, it can be isolated and used as an alternate aqueduct to feed either reservoir, if a branch of the aqueduct is ever out of service. This complete main will consist of some 22,000 ft. of prestressed concrete cylinder pipe with a short 24 in. pipe connection to the new reservoirs, and includes a watermain bridge crossing over the Assiniboine River.

(b) *Wilkes Avenue Reservoir:* The new reservoir is currently under construction and with all piping and valves will cost about $1,475,000. It is situated near the corner of Waverley Street and Wilkes Avenue in South Winnipeg. This reservoir will be of the open, earth embankment type, with a 6 in. thick plain concrete lining on the bottom and a 6 in. reinforced concrete lining on the sides. It will consist of two separate basins with piping and valves so arranged that each basin can be operated independently to facilitate cleaning and maintenance. Each basin will have a capacity of 40 million gal. and it is estimated that the additional 80 million gal. will provide Winnipeg with adequate storage facilities up until approximately 1980. This reservoir has been laid out to utilize only one half of the total reservoir site, and hence the total ultimate storage which can be

Fig. 1. Diagrammatic layout of control panels.



provided at this site is 160 million imperial gallons.

The side slopes of the reservoir embankment are 3:1 on the water side and 2:1 on the outside. The floor of each basin is to be graded so that it will drain by gravity into three drainage structures located near one end of each basin. This drainage will then be carried by a 24 in. diam. sewer to a lift station, where it will be lifted into the City's combined sewer on the adjacent street.

The concrete lining was poured in panels. The floor panels are non-reinforced concrete poured in 15 ft. strips, highway fashion with dummy contraction joints every 15 ft.

The wall panels are reinforced with bar mats and are approximately 20 ft. square with the lowest row of panels being approximately 20 ft. by 40 ft. No expansion joints are used except around rigid structures, all of the joints between wall panels are of the butt type, contraction joints with dowel bars, and 6 in. Polyvinyl-chloride waterstops are installed along all of the joints in the wall slab.

All of the inflow, outflow and inter-connecting piping at the reservoir is prestressed concrete cylinder pipe, and was manufactured at a temporary plant set up primarily for the 66 in. diam. pipe for the Greater Winnipeg Water District aqueduct.

All of the valves at the reservoir, with the exception of the two inlet valves, are to be rubber-seated butterfly valves.

The 54 in. diam. and 48 in. diam. inlet valves will control the flow from the aqueduct into the reservoir and are to be square bottom throttle construction horizontal gate valves. These will be automatically controlled according to Reservoir Levels.

Wilkes Avenue Pumping Station

The Wilkes Avenue Pumping Station now under construction is located immediately adjacent to the reservoirs. A 54 in. diam. suction header within the station is supplied from the reservoirs at both ends through 54 in. butterfly valves and it is sectionalized by a similar valve at mid point. The 48 in. diam. station discharge header with dual discharge arrangement is similarly valved and a venturi tube is located on each discharge outside the station, each rated 3 to 30 m.i.g.d.

The initial installed pumping capacity of the station is 60 m.i.g.d. consisting of two electrically driven pumping units and three dual driven pumping units. Provision has been allowed for the future installation of two 20 m.i.g.d. electrically driven

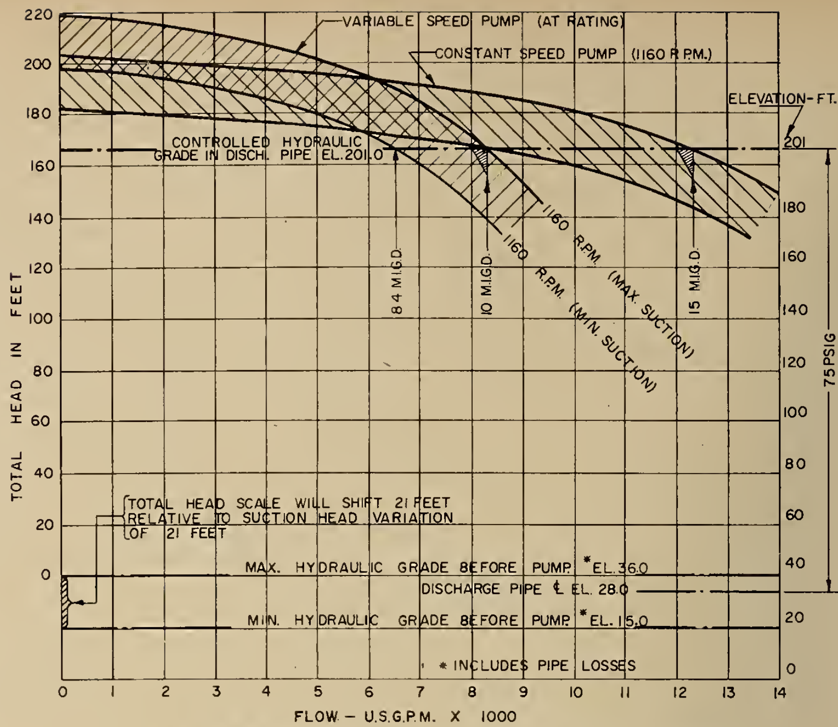


Fig. 2. Characteristic curves for 10 and 15 m.i.g.d. pumps.

pumping units to provide an ultimate installed capacity of 100 m.i.g.d.

The present pumping equipment is as follows—

Three Variable Speed Pumping Units:

Each unit is dual driven with a 450 hp. 1180 r.p.m. constant speed squirrel cage induction motor in line with a scoop-controlled fluid coupling on one side and a variable speed gas engine in line with a centrifugal clutch on the other.

(a) Pumps: Type: Double Suction, horizontal, centrifugal. Size: 16 in. suction x 14 in. discharge. Rating: 10 m.i.g.d. at 165 ft., 400 hp. at 1160 r.p.m.

(b) Gas Engine: Type: 4 stroke spark ignition V-12. Fuel: Natural Gas. Rating: 450 b.hp. at 1200 r.p.m. Governor: Pneumatic-hydraulic 0.5% accuracy 3-15 p.s.i.g. air input, 1025 to 1160 r.p.m. speed range.

Two Constant Speed Pumping Units:

Each unit is single driven with a 600 hp. 1180 r.p.m. constant speed squirrel cage induction motor. Type: Double Suction, horizontal, centrifugal. Size: 16/20 DH 20 in. suction x 16 in. discharge. Rating: 15 m.i.g.d. at 165 ft., 580 hp. at 1160 r.p.m.

Control Systems for Wilkes Avenue Pumping Station

The application of supervisory control and telemetering equipment to operate a large waterworks pumping system from a central operating and/or data logging station, is not by any means new and the systems described in this paper are of a conventional type.

Similarly, instrumentation has been employed for many years to provide a signal proportional to pressure, flow or any other variable in order to control automatically the operation of pumps and other equipment. Again, the combined "pressure-flow" system described in this paper is based on conventional practice.

However to the best of the authors' knowledge, there is no other major utility system where supervisory and automatic control have been previously combined to control constant speed (electric) pumps and variable speed, dual driven (electric-gas) pumps discharging into a closed distribution system having no elevated system storage; and where such a closely regulated discharge pressure is required under all extremes of flow demand including power failure conditions and peak load operation.

It is proposed to consider the supervisory and automatic control systems separately so as to obtain a better understanding of the basic functions of each. Although both systems have to be carefully co-ordinated and interlocked, they operate separately and either may be used to control the pumping units. Thus the satisfactory operation of the pumping station is not solely dependent upon possible weak links or operational failures of either system.

Supervisory Control System

In order to accomplish the required remote manual control of the present and future pumping units together with the telemetering and alarm requirements, it was necessary to provide for the transmission of approximately 80 functions between the existing McPhillips Street Pumping Station (referred to hereafter as the Master Station) and Wilkes Avenue Pumping Station (referred to hereafter as the Local Station). These comprise the following:—

For each variable speed pumping unit:

Stop-start and indication of the electric motor.

Increase-decrease speed control of the fluid coupling.

Stop-start and indication of the gas engine.

Increase-decrease speed control of the gas engine.

For each constant speed pumping unit:

Stop-start and indication of the electric motor.

It should be noted that these supervisory controls may only be operated when the system is selected to operate on remote manual control in preference to the normal automatic control system. This selection may be made over the supervisory control system from the Master Station or manually at the Local Station. Red and green lights however will indicate the operating state of each unit irrespective of which system is in control.

In addition, when under manual control, the units may either be controlled over the supervisory system by an operator at the Master Station or by an operator at the Local Station, as determined by the position of local/remote selector switches at the Local Station. These switches will normally be set in 'remote' to provide control over the supervisory channels, but if selected to 'local' they will block the supervisory control, and warn the Master Station operator that he no longer has control.

Controls are also provided for the 6 butterfly valves in the suction and discharge headers and for the standby generator unit.

Telemetering: The actual pump speed will be continuously telemetered and indicated at the Master Station.

The flow from the discharge header through each Venturi will be separately indicated, totalized and recorded at the Local Station and will be summated to provide total station flow which will be continuously telemetered, indicated and recorded at the Master Station.

The Master Station will also be provided with a continuous indication and for certain functions a record of the following:

Suction and Discharge header pressures

Reservoir Levels

Station Power (kw), Voltages and Temperatures

Residual chlorine dosage of the pumped water, following its automatic chemical treatment prior to pumping.

These readings will enable the operator at the Master Station either to check on the correct functioning of the pumping units if the system is under automatic control or alternately to select pumping units and control their speed to meet discharge pressure requirements for any system flow conditions if the system is under manual control.

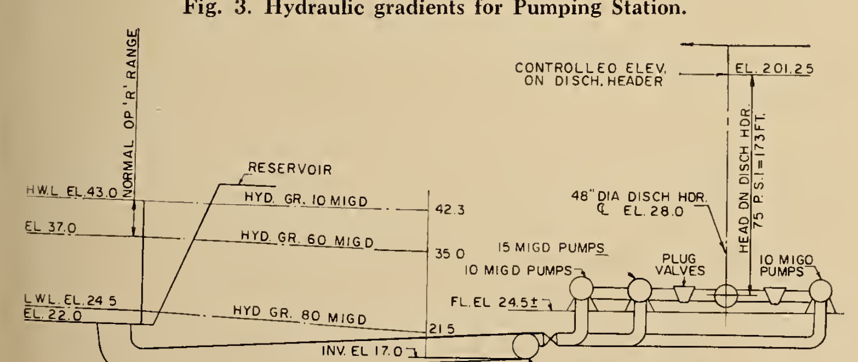
The control panel at the Master Station will be provided with a graphic diagram of the pumps and valves at the Local Station to facilitate manual control.

A diagrammatic layout of the control panels at both stations is shown in Fig. 1.

Safety Provisions and Alarms: Apart from normal overload protection, each motor and pump is provided with thermal switches in each hearing or other critical location, which, in the event of high temperature, are arranged to shut down the unit in question and initiate a common audible alarm at the Master Station. The appropriately engraved section of an annunciator panel is simultaneously lighted providing visual indication of the trouble until the condition is corrected.

Each gas engine is equipped with the normal protective devices incorporated with its automatic starting panel, which shut down the engine in the event of alarm conditions. Actuation of any of these devices also initiates at the Master Station a general alarm for the specific engine in the manner described previously for the motors.

Fig. 3. Hydraulic gradients for Pumping Station.



Alarms operated from the telemetered signals are provided to warn the Master Station operator of high or low pressure conditions, high or low reservoir levels or if the station temperature exceeds desired limits.

Alarms are also provided for general protection of the station and these comprise: gas leakage; carbon dioxide fire protection release; chlorine leakage; burglary; station flooding.

It may be noted, that, if the latter alarm reaches a preset level, valves in the ends of the suction and discharge headers close automatically to isolate the station from the system and reservoirs; and the pumping units are shut down.

Types of System: The Supervisory system was designed to operate over a single pair telephone circuit to be leased from the Manitoba Telephone System and the equipment was specified to operate within the normal communication circuit limitations, namely — Maximum impressed AC voltage, 120 v.; Maximum current, 350 ma.; Maximum signal level across a 600 ohm balanced impedance, 8 db.m. at any frequency.

All signals will be in the audio frequency range from 400 to 3400 cycles per sec. and it will be possible to provide telephone voice communication over the same channel without undue interference by the use of a low pass filter having a cut-off frequency in the order of 2000 cycles per sec.

Actually eighteen separate tone channels will be supplied. These will be utilized as follows:

Channel 1—Station check, point selection and control signals from Master Station to Local Station.

Channel 2—Confirmation signals from Local to Master Station.

Channel 3—Alarm signals from Local to Master Station.

Chanel 4 to Channel 17—Continuous telemetering signals.

Channel 18—As called for telemetering signals.

The system has an ultimate capacity to handle many additional control functions because it will use a 3 digit code for selection and control using rotary stepping switches to produce the pulses.

Selection of a point at the Master Station will set up the corresponding digital code and pressing the 'operate' button will cause the correct train of pulses to be transmitted via a tone generator to the Local Station. Here a tone receiver will supply a code translation circuit which will operate only the required relays through telephone type crossbar switches.

Within the scope of this paper it is only possible to outline briefly the type of operation and state that each code will be carefully checked to prevent false operation and that the time taken to select, check, operate and receive confirmation of a control function will not exceed 3 seconds.

The equipment generally will be designed for long life, minimum maintenance and utmost flexibility. Relays and switches will be telephone type, enclosed in dust proof cases and designed for at least 10 million operations. The audiotone equipment will be transistorized and plug-in units will be utilized where possible.

The power supplies were originally intended to be provided by a station battery of the nickel-cadmium type, but in view of the necessity of providing an alternating current power supply at 120 v. 60 cycle for the time-impulse telemetering equipment (transmitters and recorders), a standby gas engined alternator will be installed to provide all standby power. This has the added advantage that the normal ventilation fans, sump pumps and similar equipment may be maintained in operation during a Hydro System power outage.

Automatic Control System

The original concept of controlling this unattended pumping station by a completely automatic system developed partly due to economic considerations and partly to provide a more accurate control of system pressure capable of faster response to operating requirements.

Due to the physical arrangement of the pumping equipment and its control the operator at the Master Station is normally fully occupied in controlling that station manually. Until such time as the pumping equipment there is modernized to provide for panelboard control (similar to the supervisory system) additional operators on a four shift basis would be required to control Wilkes Avenue on a manual basis over the supervisory system from the Master Station. In view of such requirement and considering the present rates paid to operating personnel, an expenditure of as much as $100,000 for an automatic control system can be justified. In fact, the cost of the automatic system will not exceed 20% of that figure.

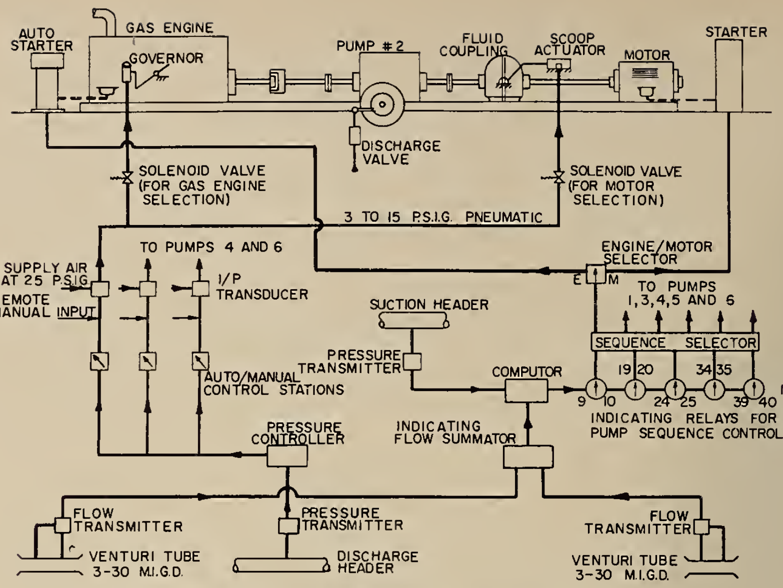


Fig. 4. Schematic arrangement of automatic control system.

Experience with the present system of manual control indicates that an experienced operator can normally maintain the system pressure on McPhillips Street discharge header within plus or minus 5 p.s.i.g. of the required 75 p.s.i.g. He does this manually by observing the system pressure and adjusting the speed of wound rotor induction motor driven pumps accordingly, or by starting or stopping additional variable speed or constant speed pumps to meet flow variations. However, at times of power failure or major system flow disturbances, pressures drop to very low values for brief periods.

Thus, the objects of the automatic control system as designed for the Wilkes Avenue pumping station may be summarized:—

(1) To sequence the starting and stopping of the various pumps as necessary to provide for variations of flow demand, while maintaining discharge pressure as closely as possible to 75 p.s.i.g.

(2) To control the discharge flow of the 10 m.i.g.d. pumps by speed variation in order to maintain discharge pressure within ± 2½ p.s.i.g. of the 75 p.s.i.g. set point.

(3) To allow for instantaneous starting and provide control for the gas engine-driven pumps in the event of power failure.

(4) To allow for selection and control of gas engine-driven pumps in the normal sequence of operation thus limiting the power demands on the Hydro system at times of peak water requirements, and reducing the overall power costs.

Type of Control: Up to the present time insufficient information has been available to permit an accurate analysis of the pressure surge conditions that may be produced in the system when the new station is completed and in operation. However, approximate calculations indicated that no excessive pressures would result due to rapid closure (20 sec.) of the pump discharge valves at Wilkes Avenue. These valves are automatically controlled with the operation of motors or gas engines to perform a check valve service as explained later.

Nevertheless, it was felt that the upsetting effect of pressure surges caused by a closed water distribution system and by manual operation of pumps at the remote McPhillips Street station on a control system sensitive only to pressure might well result in control instabilities and unwanted transient effects. Accordingly, the basic philosophy of the control system was to sequence the operation of all pumping units by the flow variable and to vary the discharge of variable speed pumping units only by the pressure variable in order to maintain the 75 p.s.i.g. set point.

The design sequencing control was based on electric switches actuated by the flow signal, which would sequence the starting and stopping of all pumps according to a pre-selected duty established by the interaction of system demand and pump characteristic curves. Speed control was based on a pressure control loop designed to provide a signal proportional to pressure deviation for control of either the scoop lever at the fluid coupling or the governor on the gas engines. Originally, preference was expressed for an all electric control scheme but because it was necessary that the gas engine hydraulic governor have a pneumatic control and because a pneumatic operator seemed most advantageous for the fluid coupling control, the overall scheme was open in the tendering stage to permit either electric or pneumatic systems to be offered. With the exception of the actual operators the scheme to be provided will be all electric.

Suction Pressure Compensation: Reference to Fig. 2. will show the pump characteristic curves having a total head of 165 ft. at discharge rates of 10 and 15 m.i.g.d. for the variable and fixed speed units respectively. Fig. 3. shows the hydraulic gradient for the station suction header and indicates that under extreme conditions when the reservoir level varies between top water and low water elevations, a suction head shift of 21 feet results.

Thus, to ensure correct functioning of the automatic control system it was essential to provide the necessary compensation for this varying level condition in the reservoir. Two methods were considered, one to continuously modify the pressure set point according to suction pressure, which would drop the controlled discharge pressure to as low as 66 p.s.i.g. (for minimum suction pressure) but still maintain rated delivery of the station. The other method and the one which will be provided, was to artificially modify the flow signal relative to suction head shift and thereby sequence additional pumps on the system at lower flows when required. This has the advantage of maintaining set point pressure at 75 p.s.i.g. but drops the rated delivery of the station by approximately 15%.

Instrumentation: Two Venturi tubes were provided, one in each end of the discharge headers together with transmitting, summating and recording instruments for measuring station flow. Similar transmitting and recording instruments were provided for station pressure and reservoir levels. In order to provide undivided responsibility for satisfactory operation of the automatic control system and also to provide additional flexibility should one system fail, it was decided to provide for separate flow and pressure transmitters and instruments for use with the automatic control equipment.

The arrangement is shown schematically in Fig. 4. for a typical variable speed pumping unit. The flow in each venturi will be determined by a flow transmitter having a lineal output signal directly proportional to flow. The outputs being linear, will be summated to give a total flow signal which will be one input to a simple computer. The other input to this computer will be supplied from a suction pressure transmitter having a reversed output of 15-0 ma. for a suction head change from 14 to 35 ft. to provide the required flow signal compensation.

Thus, the output from the flow computor will be directly proportional to flow modified by suction pressure and this will be fed in series through 5 current sensitive relays each with different settings calibrated in terms of flow. These initiating contacts will have a 1 m.i.g.d. differential spread between on-off settings and will be set selectively at increasing flows of 10, 20, 25, 35 and 40 m.i.g.d. (based on zero compensation signal). The setting and differential of these contacts may be independently adjusted in the field to suit the operating conditions.

A pressure transmitter will provide a signal proportional to discharge pressure which will be fed into a process controller giving 3 mode control i.e.

(a) Proportional (proportional to error)

(b) Integral or reset (proportional to magnitude of error)

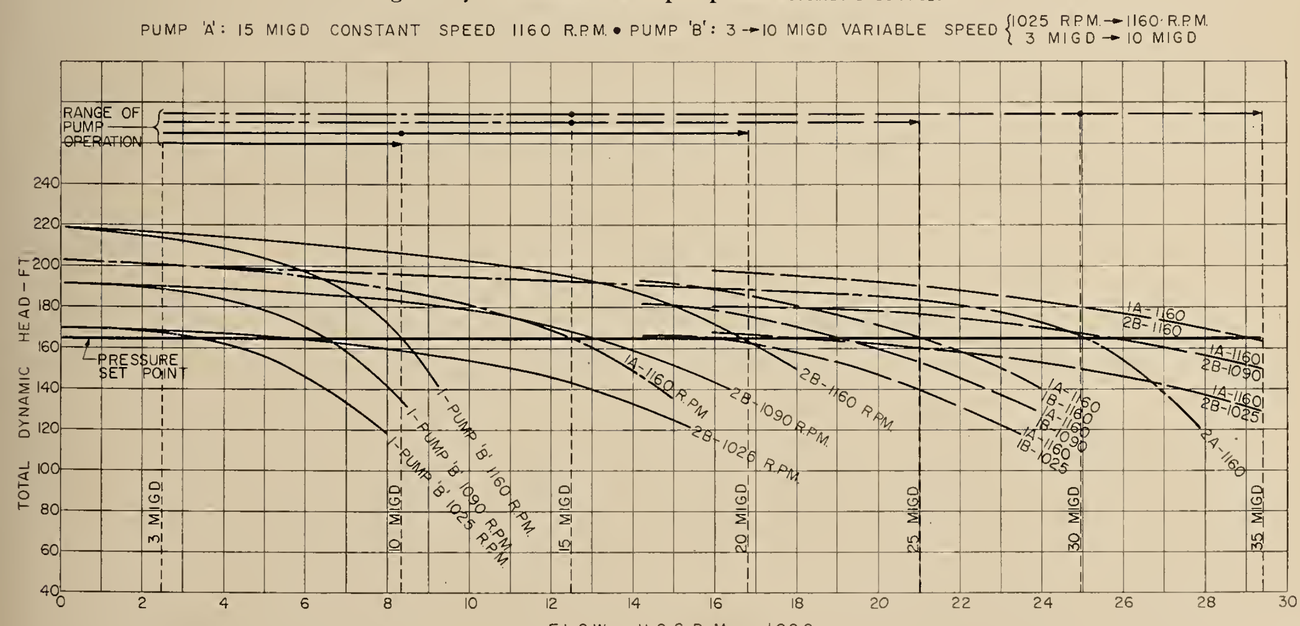
(c) Derivative or rate (proportional to rate of change of error)

The output signal from this controller will be directed through the auto side of an automatic-manual selector into 3 current/pressure transducers to provide a pneumatic signal which will operate any or all the speed regulating operators, as selected. Under manual control either locally or remotely over the supervisory system a manually actuated potentiometric signal will be fed into the current/pressure transducers instead of the automatic signal from the pressure controller. Provision will be made so that the manual signals can be matched to the controller output signal in order to effect a 'bumpless transfer' when changing from manual to automatic control.

Pump Discharge Valve Control: Associated with each pump is a rotating plug valve automatically controlled to serve both as shut-off valve and check valve. The valve has an hydraulic actuator operated by a four way solenoid valve, the control of which is interlocked with the motor and gas engine starters so that a pump always starts and stops against a closed valve. On valve opening this is accomplished by a pressure switch which initiates the opening solenoid after satisfactory upstream conditions have been attained. On valve closing, the 'stop' signal first of all energizes the 'closing' solenoid and, when the valve has fully closed a limit switch then shuts down either the motor or gas engine.

The normal or closing time will be between 2 and 3 min. but when used

Fig. 5. System demand and pump characteristic curves.



as a check valve for either power failure or other emergency shut down conditions, the fast-closure solenoid will provide an accelerated closure time of 10 to 20 sec. and, in any case, will be set to the fastest time consistent with acceptable pressure surges.

These valve operating times provided some complication to the automatic control scheme and consideration had to be given at pump changeover points to allow for the effect of gradually decreasing flow from the pump to be stopped and/or that of gradually increasing flow from the pump being started, and yet at the same time allow the pressure controller signal to maintain the necessary degree of speed control to suit the pressure conditions arising as a result of this changeover.

Safety Provisions: Limit switches on the valve in conjunction with a time delay relay will be used to detect a fault condition so that if either the pump fails to start or the valve fails to open, an alarm will be sent over the supervisory system and a similar pump pre-selected to standby duty will be started up.

Mechanical failures such as a broken shaft or faulty fluid coupling could result in reverse flow through the pump which would give rise to excessive speeds and cause damage. To provide for this condition, reverse flow protection was specified for each pump and this will be obtained from the DC tachometer generators, which are provided for telemetering each pump speed. In the event of reverse flow a negative signal will be used to operate a relay which will close the discharge valve, shut down the driving unit and send an alarm.

Operation of Pumping Units: Fig. 6 shows the pumping curves related to the system demand from 3 to 35 m.i.g.d. and the normal sequence of operation will be as follows:—

(a) Increasing Flows — Normal Hydro Power:

Flow mi.g.d. (based on Reservoir top water level)

0—Start one pump manually and switch to auto.

3 to 10—1st duty 10 m.i.g.d. variable speed pump electric motor operating and speed control signal acting on fluid coupling.

10—Start 2nd duty m.i.g.d. variable speed pump at the speed set by the control signal.

10 to 20—1st and 2nd duty variable speed pump electric motors operating and both respond equally to control signal and share the load.

20—Start 3rd duty 15 m.i.g.d. constant speed electric motor.

—Initiate shut-down of 2nd duty pump by closing plug valve.

20 to 25—3rd duty constant speed pump supplying base load of 15 m.i.g.d. and 1st duty variable speed pump responds to speed set by control signal.

25—Restart 2nd duty pump, either electric motor or gas engine as selected, at control signal speed.

25 to 35—3rd duty constant speed pump supplying base load of 15 m.i.g.d. and 1st and 2nd duty variable speed pumps respond together to control signal and share the balance of the load.

For increasing flows up to the ultimate station capacity the sequence will be very similar using the constant speed pumps as the base load with one and/or two variable speed pumps providing the balance according to the pressure controller signal.

(b) Decreasing Flows:

Flow m.i.g.d.

24—Initiate shut-down of 2nd duty 10 m.i.g.d. variable speed pump, i.e. close plug valve and block speed control signal to maintain low speed.

—1st duty 10 m.i.g.d. variable speed pump will increase speed to compensate for above.

19—Restart 2nd duty pump at controlled speed.

—Initiate shut-down of 3rd duty 15 m.i.g.d. constant speed pump.

9—Initiate shut-down of 2nd duty pump, i.e. close plug valve and block speed control signal.

(c) Power Failure and Restoration:

—All electric driven pumps shut down and all discharge valves will close rapidly.

—Standby generator will start up and provide power for the supervisory and automatic control system and the discharge valve operating controls.

—All gas engines selected for duty start and the normal sequence selector is by-passed.

—The appropriate discharge valves open and the gas engines together respond to the speed control signal.

—Upon power restoration, all gas engines remain operating and discharge valves remain open.

—When the operator at the Master Station is ready to resume normal operation, the control may be set to 'manual', the gas engines shut down and the electrically driven units started in the correct sequence to suit the necessary flow demand. The control may then revert to 'auto'.

It may be noted that for economic reasons it was not practicable to provide for selecting the desired pump duty sequence over the supervisory system. This will probably be changed not more than once per week and a manual plug and jack type selector has been included in the Local Station control panel. An indicator only has been provided at the Master Station, and this must be manually set to agree with the sequence selected at the Local Station.

All pumps have an elapsed time meter which will record the number of hours the pump has been in use and this will operate from the (electric motor driven only) starter circuit.

Silver Falls Project

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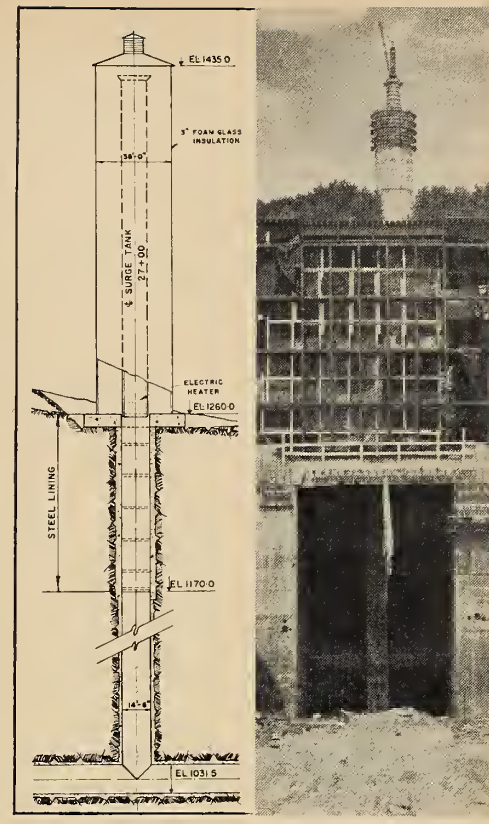

This paper will be presented at the Annual General Meeting of the Engineering Institute of Canada, Winnipeg, May 1960.

Silver Falls Generating Station was built in response to the continuous demand for more electrical power in Northwestern Ontario. The powersite is located approximately 30 miles northwest of Port Arthur and is on the Kaministikwia River. It is readily accessible by road and rail, being about 12 miles north of Highway 17 at Kaministikwia. During its construction, it became a main construction attraction for the Lakehead and its surrounding area.

The station has an installed capacity of 45,000 kw. designed for both base and peak loading and for remote control operation. The essential features consist of an intake structure, a 300 ft. intake shaft, a 2 mile tunnel, a surge shaft and surge tank, and a single unit powerhouse.

Hydraulic power is derived from the 350 ft. head between Dog Lake and Little Dog Lake on the Kaministikwia River. Dog Lake is the storage reservoir for Silver Falls and is also the headwaters of the Kaministikwia River which falls some 775 ft. in its 50 mile course to Lake Superior. Part of this head, 194 ft., is utilized by Kakabeka Falls Generating Station, developing 34,000 hp. Kakabeka is quite an old plant, having been in operation since 1906.

History and Preliminary Work

SILVER FALLS, under flow in its natural state, is quite a pretty sight, and consists of a series of falls and rapids nestling in the upper valley of the Kaministikwia River, with a predominance of silver birch in the surrounding bush.

In the early days, access routes to western Canada passed through this area, either up the Kaministikwia River, with portages around the various falls to Dog Lake, or overland by the Dawson trail to Dog Lake. The old landing on Dog Lake was located about 100 yd. west of the intake.

Its history as a power development is the story of the search over half a century for a practical and economic diversion route for its water; the main problem being to provide a secure hydraulic conduit. The Kaministikwia Power Company made site surveys in 1906. Various studies and proposals have been made since then, including tunnel diversions and surface canals, single-stage developments and multiple low-head developments ranging from 13,000 to 40,000 hp. However, it was not until 1945, when Ontario Hydro acquired power rights on the Kaministikwia River, that a detailed survey was made.

The results of these investigations indicated no apparent problem with low-head multiple-stage schemes but there were major geological problems associated with the more attractive single-stage schemes: too low bedrock elevation adjacent to the intake; a tunnel horizon which was too deep for economic construction; also, soil and ground water conditions were not favourable for excavation of open-cut canals. This all pointed to the need for still further investigations.

So, in 1955, as power demands increased, more intensive field investigations and further surface mapping were resumed and in 1956, by means of a seismic survey the whole diversion area was delineated between Dog Lake and the Kaministikwia River Valley. This investigation, in spite of the irregularity of the bedrock, finally disclosed an area having sufficiently high bedrock in which to locate a diversion tunnel, intake and powerhouse. Following this, late in 1957 and throughout the winter, an accelerated program of investigation was carried out to finalize site locations. This included further seismic work, intensive drilling of intake and powerhouse areas; deep borings of up to 450 ft. through overburden along the tunnel line, to check the seismic report and determine rock conditions at the tunnel horizon. Deposits of granular materials were identified, and the location of the intake channel on Dog Lake and the nature of the tailrace channel improvements in the Kaministikwia River were determined.

On February 3, 1957, Commission approval was finally obtained for the construction of a 45,000 kw. station to be completed by September 1, 1959.

Geology

The general topography of the area

is hummocky uplands with elevations ranging from 1,000 to 1,500 ft. above sea level. Bedrock outcrops occur along the Kaministikwia Valley and along the shore of Dog Lake, reaching Elevation 1,400 ft. in places. Except for these scattered outcrops, most of the bedrock in the area is overlain by layers of glacial and post glacial sediments having an accumulated depth of as much as 800 ft. This material consists of glacial moraine and shallow-water deposits. The Kaministikwia River has cut its way through this material and so eroded the bedrock that a series of falls and rapids exists in the river valley.

As a result of seismic surveys, a ridge of bedrock was found in the area of the proposed project, running roughly parallel to the Kaministikwia Valley. This ridge falls off steeply on the east side into the old glacial valley and on the west to the present-day Kaministikwia Valley. A profile of this ridge indicated a relatively flat bedrock surface with a deep depression near Dog Lake and a rock knob on the lake shore.

As seismic results are only accurate to within 10 to 20% of the depth range, intensive diamond drilling was carried out along the ridge in the area of this depression to find the lowest point of the depression so that the tunnel could be located in an adequate thickness of rock.

Diamond drilling was done every 1,000 ft. along the tunnel line with concentrations in the locations of proposed structures. The drill cores revealed generally competent rock, consisting of massive paragneiss and granite throughout. However, a faulted zone about 500 ft. long was found in the depression area, and another in the location of the intake shaft, both being potential sources of water loss.

As a safety precaution, the intake shaft area was grouted prior to excavation, and as the tunnel approached the depression area, diamond drill holes probed up to 300 ft. ahead and angled up to 30° to check the condition of the rock and the amount of rock cover.

A seepage problem also existed, as the water table was found to be high above the tunnel line throughout its length. This resulted in leakage through joints and fissures while the tunnel was being drilled.

Hydrology and Turbine Selection

Dog Lake is a perennial storage reservoir for Silver Falls Generating Station. Storage capacity is 578,000 acre feet for a 16 ft. range between elevations 1367 - 1383. Dog Lake watershed covers 1,340 sq. miles and extends from a line due north of Fort William northwest to the headwater of the Seine River near Muskeg Lake. Average yearly inflow is 1,100 c.f.s. With a net head of 330 ft., this indicated a unit capacity of 40,000 hp. for base load.

However, a 60,000 h.p. unit using 1,800 c.f.s. was installed as the peaking power obtained was cheaper than thermal power. Also, the 1,800 c.f.s. required for 60,000 hp. would be utilized by the Kakabeka plant in the future, when the very old units there are replaced by a larger installation. Further, the extra capacity would provide a 35 mw. or 6.6% reserve in the 536 mw. system by December, 1960. Also,, this reserve would augment the loss of peak from Hydro's Winnipeg and English River plants during June (a high load month) as a result of high tailwater.

Fig. 1.

Originally the N.T.W.L. was 1025. With a N.H.W.L. of 1375, this gave 350 ft. gross head. Tunnel losses were estimated at 20 ft., leaving a net head of 330 ft. Subsequent channel improvements amounting to a gain of 6 ft. lowered the N.T.W.L. to 1019, with a range 1016 to 1022. This increases turbine output to about 61,000 hp. Actual maximum full gate output is about 3% in excess of the nominal rating of 60,000 hp.

A synchronous speed of 240 r.p.m. was proposed by the manufacturer and adopted for design. The corresponding specific speed of 42 resulted from the latest improvements in blading, and indicates continuing development of higher speed hydraulic turbines in an effort to reduce weight and costs of prime-mover equipment.

The turbine is a modern high speed Francis turbine which, by comparison with designs available ten years ago, represents a 25% increase in synchronous speed. This in turn allows proportionate savings in unit costs and certain other fringe benefits.

A hydraulic feature of this turbine is the deep setting of the runner. To meet the specified performance and cavitation standards with this high specific speed, the manufacturer requested that the centre line of the distributor be set 6 ft. below the minimum tailwater. During periods of high tailwater, this meant a submergence of as much as 15 ft. to the bottom of the runner blades.

To allow synchronous - condenser operation of the generator, a tailwater depression system is provided for the turbine, to minimize the quantity of motoring power.

Structural Features

Intake: The intake structure is a conventional headblock type which, in combination with the transition section behind it, was designed to be stable without assistance from backfill. It was constructed behind a natural earth barrier of somewhat limited durability. However, on completion of the intake structure and installation of the service gates, this structure provided an effective bulkhead against Dog Lake during construction of the intake shaft.

Two air vents are built into the structure: a small one in the structure designed to deflect any back surge of

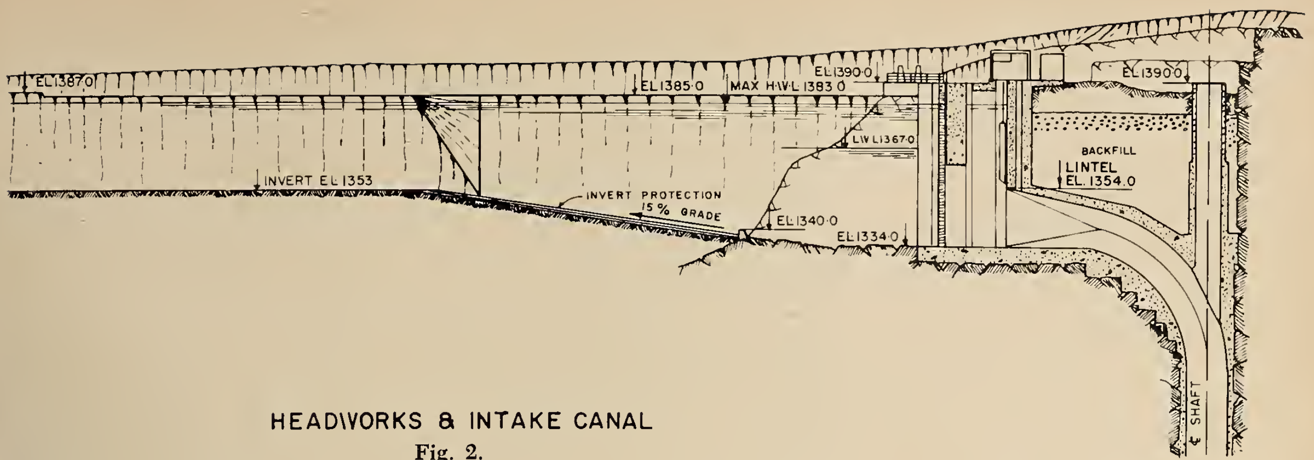

Fig. 2.

water into the intake bay, but allowing air movement through deck gratings and hoist house louvres; the larger vent is a 9 ft. diam. shaft located directly over the intake shaft and extending to the surface. This vent relieves whatever trapped air accumulates in the tunnel during filling operations; also this vent shaft provides a future access for tunnel repairs.

Although standard trash racks and service gates are stored outside, there is no permanent gantry, since the infrequent lifting operations can be done by a mobile crane.

Tunnel: Economic studies of lined and unlined tunnels indicated a lined tunnel would be cheaper to maintain and more secure against the possibility of loose rock blocking the tunnel in the future, which would necessitate major repairs. A nominal lining thickness of 18 in. was selected because the arch action of such a thickness provides sufficient strength to withstand the external water pressure; also 18 in. was recommended for construction. A thickness tolerance down to 13 in. was allowed in isolated local spots caused by tights when drilling the tunnel.

The tunnel diameter of 14 ft. 6 in. was selected entirely on the basis of economic studies, weighing the cost of constructing a certain size of tunnel against the power loss in friction through it.

The concrete lining is designed to withstand an external water pressure to ground water level, which in places is higher than Dog Lake.

The tunnel invert was set horizontal at elevation 1030. This level was high enough to prevent any tunnel flooding from Little Dog Lake during construction, and low enough to provide a reasonable rock cover when tunnelling through the rock depression area. It also enables the tunnel to be drained, either for inspection or if the penstock valve ever failed.

Powerhouse: Two locations for the powerhouse were considered feasible: a site on Silver Lake, shortly up-river from Little Dog Lake, and the chosen site on Little Dog Lake. The latter was considered somewhat more economical: a greater head was available, there being a rapids between the two sites; there was the prospect of a lowering of Little Dog Lake by excavation activities, which would not have led to any power improvements at the former site; a larger surge tank would have been necessary at the former site; the present tunnel line is the more advantageous of the two, geologically. An underground powerhouse was considered rather more expensive than a surface structure.

The powerhouse substructure is set in rock as high as the generator floor. Plastic waterstops and water-proofing are used throughout the substructure to withstand tailrace flooding also as high as the generator floor.

The penstock and the substructure concrete are mutually isolated by means of a special caulking material, so as to avoid spalling the concrete wall around the penstock during movement of the latter. This also eliminates stresses in the penstock end caused by the rigidity of this wall. The penstock itself is embedded in a concrete envelope for anchorage purposes; a gravel fill is placed on top of this to absorb the impact of rock falls.

The superstructure houses the whole powerhouse floor area. The erection bay is located on the downstream deck, permitting the overhead powerhouse crane to handle the draft tube service gates, thereby eliminating a trailrace gantry. Floor hatches permit removal of the penstock valve, the generator and shaft, and provide access to the transformer service bay on the turbine floor. The generator floor is designed for a loading of 1,000 p.s.f. between crane columns and at least 300 p.s.f. elsewhere. The superstructure steelwork bents are a rigid frame type, and these are covered by insulated wall and roof cladding which features aluminum on the outside.

Surge Tank: Since a two-mile pressure tunnel was to be the main feature of the system, a surge tank was required to disperse the water-hammer pressure resulting from any sudden flow stoppage when rejecting the unit load. In addition, in cases of sudden power demand, the surge tank provides a source of high-head water which helps to accelerate water in the tunnel.

It is desirable to locate a surge tank as close to a powerhouse as possible. In this case, the location was fixed at a position 885 ft. upstream of the unit, after weighing up economic considerations like height of tank, rock and soil profiles along the tunnel line, accessibility and cost of the shaft; it was more expensive to locate the tank anywhere nearer the powerhouse.

Both elevated and standpipe types of tank were considered permissible and the decision to use the latter resulted from a comparison of tenders. Studies showed that the differential tank would be 38 ft. diam. and stand 180 ft. above a base at elevation 1260; the internal riser being 12½ ft. diam. and 170 ft. above the base. The surge shaft is steel lined for 90 ft. below the base. The differential action occurs through ports totalling 25% of the conduit area.

Although the most rapid unit closure time is 8 seconds, design was based on a 4 sec. closure. The performance of the surge tank under all conditions of headwater level and load rejection was evaluated, using a computing machine.

Field tests since installation have proved satisfactory, and further tests will decide the final port area.

Block Dams: Along with the program of constructing a generating station, it was decided to carry out repairs and replacement work on four of the five existing block dams which had deteriorated.

Sonic tests were performed on the concrete cores of three of these dams; they proved to be in poor condition.

As it would have required a major dewatering program to renovate them, it was decided to build new dams of compacted earth, located downstream from the originals.

The best local core material was found to be a compacted silt. For compaction, this material had a very limited range of moisture content, the optimum being 14%. This necessitated dry weather conditions during handling and compaction, along with close control of moisture content.

Filter and riprap material was placed on top of the silt, and the final shape consisted of a 17 ft. wide flat top, upstream and downstream slopes of 2½:1 and 2:1 respectively, and a maximum depth around 30 ft.

Repairs to a sluice control dam consisted mainly of concrete renovations and gate replacement.

Intake Channel Design: It was necessary to ensure that in winter a continuous sheet of ice formed in the forebay, so as to avoid clogging the intake during periodic breakups. Hence, an unusually large and deep channel was necessary. In the section designed, surface velocity is kept to less than 2 f.p.s. The maximum and minimum depths are 30 and 12 ft. respectively, and the ice cover is not less than 2 ft. thick.

Tailrace Channel Design: Between Little Dog Lake and Crooked Rapids, a 2 mile stretch, the river level drops by about 15 ft. Economic studies showed that 15,000 cu. yd. of rock and 100,000 cu. yd. of silt material had to be removed to eliminate 6 ft. of that head. The rock excavation was carried out, but only 30,000 cu. yd. of the tougher clay was removed, at strategic points, as it was believed that the remaining 70,000 cu. yd. would be eroded in time by the higher velocities created.

Research: In addition to the continuous job of concrete control, research work was performed in the following fields: Petrographic examination of rock to ascertain drilling conditions prior to tunnelling; checking of blasting methods and detonating circuits for reasons of safety; installation of circuits and strain gauges on the penstock walls, and in tunnel and shaft linings, for future measurement of stresses in the concrete and steel; installation of electric pressure cells to determine head and friction losses in the tunnel, and also in the surge tank, for comparison with results obtained by using manometers; sonic testing of concrete quality in the original block dams; testing and control of moisture content of the core material used in the new earth dams; in-service testing of the turbine, generator and surge tank.

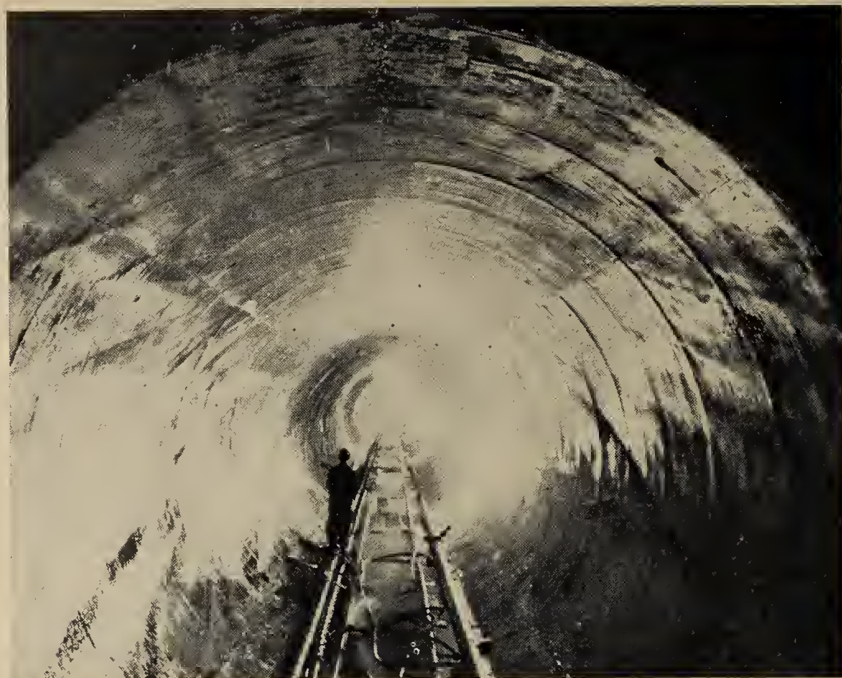

Fig. 3. Fogging operations in the tunnel to maintain humidity during concrete curing.

Mechanical Features

Headgate: Intake is controlled by a single headgate operated by a hoist located on the headworks deck and enclosed by a housing which is removable for maintenance purposes.

The gate covers a clear opening 18 ft. wide and 20 ft. deep. It weighs 55,000 lb. and is designed for a 44 ft. head on the sill. The gate is a face-roller type, has downstream sealing, and a pointed edge on the sill. It is also provided with aeration holes to reduce downpull on the hoist.

The hoist is designed for a hoisting speed of 5½ f.p.m. and a lowering speed of 12 f.p.m.; it is powered by a 15 hp: squirrel-cage induction motor. The gate is lowered without power and braking is effected by an overloading type fan brake. A solenoid-operated holding brake is fitted to the motor shaft, the coil being energized to release it.

Inlet Valve: The inlet valve is located immediately upstream of the spiral scroll-case. It is a straight-flow type, having a bore of 9 ft. It is able to close in an emergency under the maximum turbine flow of 2,100 c.f.s. and a differential pressure of 240 p.s.i. Both opening and closure time is one minute.

The valve body is spherically shaped and consists of an upstream and a downstream portion fabricated from formed plates, heavily ribbed and flanged for bolted connection. The upstream portion is provided with two bearings which support the hemispherical door. The downstream portion carries the internal extension pipe.

The hemispherical door, fabricated from 4 in. formed plates, transmits its load to the valve body through two cast steel trunnions welded to the dome structure.

Sealing of the valve is effected by a pressurized moulded rubber, carried on the upstream end of the internal extension pipe, and seating against a stainless steel annulus provided on the downstream side of the door. Seal pressure is taken from the penstock upstream of the valve through an interlocked control, which prevents the valve door from opening before the seal has been withdrawn. The valve is operated by a servomotor, using penstock water pressure: the opening pressure from the downstream side of the valve, and the closing pressure from the upstream side. Before opening, the downstream side of the valve is primed through a manually operated by-pass.

The valve is connected to the scroll casing by a Dresser coupling which allows small horizontal movement. The valve is supported on heavy footings which can make a small horizontal movement on bronze thrust plates. The valve weighs 90 tons.

Turbine: The 60,000 hp. Francis turbine has a cast steel runner and a throat diameter of 100 in. A stainless steel overlay was applied to the back of the blades in areas of heavy pitting, as determined from model tests.

The speed ring consists of cast steel top and bottom rings, welded to steel plate vanes. The scroll case has an inlet diameter of 9 ft., and is fabricated from rolled plate varying from ⅝ in. to 1-⅜ in. thick. For purposes of field erection, it was made in two parts which were bolted together in the field. The casing is designed to withstand 235 p.s.i., which includes a 64% pressure rise resulting from a rejection of full load in 4 sec., while operating under the rated head of 330 ft.

The turbine shaft, 26 in. nominal diameter, is provided with a self-pumping bearing immersed in an oil bath. This bearing is supported on the headcover which is of fabricated plate construction.

The speed of rotation is controlled automatically by a governor mechanism, which is sensitive to changes of load demand, and which actuates the wicket gates through two servomotors.

Crane: The major equipment located in the powerhouse is serviced by an overhead electric crane travelling on rails spaced 39 ft. 10 in. apart. It is provided with a main and an auxiliary hoist; the main hoist having a capacity of 175 tons when operating at a speed of 5 f.p.m.; the auxiliary hoist having a capacity of 25 tons when operating at a speed of 40 f.p.m. Each hoist is driven by a 75 hp. wound-rotor motor, through a gear reduction, and is provided with both a mechanical load brake and an electric holding brake.

Auxiliary Mechanical Systems

Compressed Air: Compressed air for the generator brakes and the station service air system is supplied by a single compressor rated at 100 c.f.m. and 100 p.s.i., with one air receiver.

Compresed air for the draft tube water depression depresses the water level in the draft tube to 4 ft. below the runner when the unit is operating as a synchronous condenser. The equipment consists of a single air compressor identical to the station air compressor and two air receivers of 300 cu. ft. vol.; it is operated by an electrodetype level control.

Compressed air for the governor and switchgear is supplied by two compressors, each rated at 37 cu. ft. and 350 p.s.i.

Cooling Water: Water for the generator air coolers, turbine guide bearing, generator thrust bearing, air compressors and turbine runner bands is supplied from the tailrace by a deep-well pump rated at 1,400 US gal. per min. 75 ft. head. Alternate supply can be obtained from the penstock fire header.

Generator Damper Control: Four intake and four discharge louvres on the generator are operated by pneumatic air motors, so that warm air is circulated inside the powerhouse during winter.

Oil System: Lubricating oil for the generator thrust bearing, the turbine guide bearing and the wicket gate servomotors is supplied by 40 Imperial gal. per min. filter press and pump, and three handling tanks of 1,200 Imperial gal. each.

Transformer oil for power and station service transformers is also supplied by a 40 Imperial gal. per min. filter press and pump, plus a 125 Imperial gal. per min. booster pump and three tanks having a total capacity of 6,200 gal.

Fire Protection: General fire protection consists of 9 hose stands, each equipped with 75 ft. of hose, and a combination fog and stream nozzle. Water is supplied from the penstock fire header at 150 p.s.i. This fire header also supplies the generator sprinkler rings and the transformer deluge system.

Power and station service transformers are protected by deluge systems which are actuated automatically by temperature control devices.

A CO2 system protects both the generator and the oil room; it is fired either by thermostats or manually. Equipment consists of one in-service and one reserve bank of thirty-two 50 lb. cylinders.

Both local and remote warning devices are used in conjunction with the fire protection systems.

Dewatering: Accumulated drainage water in the sump is emptied by one deep-well pump rated at 450 US gal. per min. at 47 ft. head. The draft tube is dewatered by one deep-well pump rated at 2,500 US gal. per min. at 20 ft. head. Both pumps have automatic level controls.

Water for both domestic use and the turbine carbon seal is supplied from the tailrace by a deep-well pump rated at 30 US gal. per min. at 145 ft. head or from the penstock fire header. The domestic water is chlorinated.

Electrical Features

The Silver Falls generator is a 13,800 v. 3 phase, 60 cycle, 240 r.p.m. unit equipped to operate either as a generator rated 50,000 kva. at 90% power factor or as a synchronous condenser rated 30,000 kva. re-active at zero power factor. Class B insulation is used by the manufacturer and the generator is designed to deliver its rated output continuously with a maximum temperature rise in the rotor and stator windings of 60°C over an assumed ambient of 40°C. In addition, the unit is capable of operating at 115% of its rating with a maximum temperature rise of 80°C above the ambient.

The generator is cooled by a closed air system with air-to-water heat exchangers. Four air ducts connected to openings in the generator frame provide hot air for heating the powerhouse. Dampers in each of the hot air ducts close automatically when the generator CO2 fire protection system operates. The generator air system is separated from the turbine but by a steel plate membrane between the bracket openings.

Three triple unit current transformers on the stator neutral leads are used for metering and relaying purposes and are located in a cutout in the generator pedestal. A 13,800-230/115 v. grounding transformer in a single-cell cubicle assembly is connected between the star point and ground. Primary balanced type split phase current transformers are located on the main stator leads in the air housing. An automatic high speed continuously-acting voltage regulator and a motor-operated voltage adjusting rheostat are provided with the unit.

The 13.8 kv. switching is contained in a single metalclad structure and consists of one 2,500 amp. airblast generator breaker with isolating switches and two pneumatically-operated 600 amp. load interrupter switches for primary switching of the station service transformers.

Two 600 kva., 3 phase, 13,800-600 v. station service transformers with on-load tap changers are provided, with switching so arranged that one transformer is normally loaded and the other standby. In the event of a failure on the normally loaded transformer, the load is automatically transferred to the standby unit. Power for the intake structure is supplied from the 600 v. station service panel in the powerhouse, stepped up to 12 kv. for transmission along a 5.5 mile wood pole line, then stepped down to 600 v. at the intake. This pole line parallels the access road to Big Dog Lake for ease of maintenance and was erected early in the project to provide construction power at the intake structure. Transformation consists of a bank of three 25 kva., distribution-type units located on a wood pole structure at each end of the 12 kv. line.

Three 17,333 kva., single-phase, 60 cycle, 13.2-69.86 kv. oil-immersed forced-air-cooled power transformers, connected delta-wye, step up the generator voltage to a nominal transmission line voltage of 121,000. A spare power transformer has been provided.

A single circuit, 115 kv., steel-tower transmission line 8.8 miles long, links Silver Falls Generating Station with the Commission's existing 115 kv. line from Moose Lake Transformer Station to Port Arthur Transformer Station No. 1. The connection is made at Conmee Junction, 20 miles from Port Arthur.

Supervisory control equipment operating via power line carrier channels is used for remote operation of the plant from Port Arthur Transformer Station No. 1. Twenty operations including starting and stopping the generator are remote controlled. Supervision of the generating station equipment is maintained by visual indicators and alarms which will indicate such occurrences as relay operations, over-temperatures, low oil levels, etc.. Telemetering provides continuous indication at the controlling station of generator vars and wicket gate positions; nine other electrical and mechanical quantities such as generator watts, gate limit position, headwater level, etc., are telemetered on an "as called for" basis. A six-pair No. 19 Alpeth-type aerial cable strung on wood poles along the tunnel right-of-way provides a voice circuit and a metallic extension of the supervisory and telemetering system from the powerhouse to the intake structure.

Construction Camp and Plant

Camp facilities adequate for 350 construction personnel were installed; additional labour commuted each day from the Lakehead.

Aggregate crushing was done by a portable crusher, which turned out 40,000 cu. yd. of 1½ in. and 40,000 yd. of ¾ in. aggregate from the tunnel rock. Finer material was readily available for screening and some 40,000 tons of sand was stockpiled.

100 lb. compressed air was supplied by 3 large compressors. Power was supplied from Kaministiquia, 10 miles away, through an 8,000 v. construction line directly to the site. Steam was supplied by three 100 hp. portable boilers at 100 p.s.i. Water supply was taken from a 10,000 gal. wood-stave tank erected on a Bailey tower, the tank being topped up by a 400 gal. per min. pump.

The concrete mixing plant featured a 75 cu. yd. mixing-bin capacity, a semi-automatic batcher and two 2 cu. yd. mixers having an output of 85 cu. yd. of concrete per hr. Aggregate was fed into the gravel hoppers from stockpiles by a front-end loader, and thence by conveyor belt to the mixing plant. Cement was transported from the Lakehead in bulk-cement trailers of 400 bag capacity and stored in an 11,000 bag steel silo. From there, it could be distributed either to the mixing-plant hopper or direct to the batching bin, by means of a screw conveyor or a bucket elevator.

Construction

In March, 1957, construction began on the access road located along the east bank of the river from Kaministikwia to the powerhouse, and another to the intake and control dams. This work included 8 miles of realignment and improvement of the existing township road from Kaministikwia to Little Dog Lake, 2 miles of new road to the powerhouse site at the north end of Little Dog Lake, 5 miles of new road from Little Dog Lake to the intake area on Dog Lake and 2 miles of new road from the intake to the dam area.

No major problems occurred during road construction, materials being quite plentiful. The maximum grade was 10%.

A temporary camp was set up from March, 1957 to November, 1957, at which time the permanent camp was completed and located near the powerhouse. Some of the features of the final camp included extensive dormitory housing for the employees, a large cafeteria, a recreation hall, games rooms, guest and staff houses, offices, workshops, service shops, changing sheds for the miners, a trailer park and full services for the whole camp.

Excavation of the approach to the powerhouse and portal area began in July, 1957 and consisted of removing a deep overburden of silt and boulders totalling 110,000 cu. yd.; this was completed down to tunnel invert by October 1, 1957. Tunnel railway track was laid in a rock cut around the west side of the powerhouse, extending across the tailrace cofferdam to the disposal area in Little Dog Lake.

The rock surrounding the portal was generally in good condition, although some rock bolting of the face was done. A portal shed was constructed over the tunnel entrance, for protection against rock falls.

Tunnelling progress began slowly due to proving-up of both the organization and equipment. By mid-November, a speed of 27 ft. per day was reached, 640 ft. being done at this rate. By mid-January, 1958, a steady advancement rate of 42 ft. per day was developed, and this was maintained for the rest of the 10,000 ft. Tunnelling was completed by August 15, 1958. Bonus incentive had a marked effect on progress. A rate of 60 ft. per day could have been made, but was considered unwise for safety reasons. The main restraint on advancement was the policy of allowing a maximum length of drill steel of 16 ft.

Generally, rock was good in the tunnel. Steel arch supports were used in only one area, although extensive rock bolting of the roof was done as a precautionary measure. Some 120 men were employed in three shifts covering drilling, mucking, rock disposal, track laying,, installation of services and maintenance of equipment. Equipment used included a drilling jumbo of 7 drills, a 130 hp. electric mucking machine, 3 diesel locomotives with exhaust filters and a train of 5 cu. yd. side dump cars. Track consisted of 30 lb. rail at a 3 ft. gauge. Compressed air, water and drain pipes were hung along one wall, and power and lighting circuits were fastened to the other. Ventilation was obtained by using a 30 in. fresh air pipe in conjunction with axial-flow blowers; the air was heated by a 1,250,000 B.t.u. oil-fired furnace, operating near the portal.

The average number of blasting holes was 70 per round, 5 lb. of powder being used per cu. yd. of rock. This blasting arrangement produced fairly small broken rock, thus simplifying mucking operations. The average overbreak was 8 in. on the nominal radius.

Wet conditions were encountered in two areas: one approaching the depression area and the other about 2,000 ft. in from the portal. On approaching the rock depression area, a diamond drill probed forward and up at an angle of about 30° for 100 ft., to reconnoiter any dangerous rock or water conditions; this also being an added check on the rock cover. In this region, a 30 ft. drill hole was used to probe directly ahead, prior to each blasting round, as well.

To guide the drilling crew, the tunnel face was spray-painted along both vertical and horizontal centre lines and around the perimeter before each round of drilling. A full cycle of excavation was completed during every eight-hour shift.

Work on the surge shaft began about mid-January, 1958. This was done by the so-called Swedish method. In this, a churn-drill sank a 9 in. hole from the surface to the tunnel; a hoist cable was threaded through the hole. A 6 ft. diam. pilot shaft was raised from the tunnel by work done from an access cage, which itself was hoisted up and down on the cable. Blasted rock was collected in timber bins at the bottom of the shaft and fed into the mucking cars automatically. The full sized 17 ft. 6 in. diam. shaft was subsequently slashed out by blasting from the top downwards.

Work on the intake shaft began about August 20, 1958 by the same method as for the surge shaft, except that the cable hole was obtained by using a 4 in. diamond drill. Fouling of the hoist cable was found to be a difficulty with the smaller-sized hole. The vertical alignment of the cable hole was about 2 feet off-centre. About 3 lb. of powder per cu. yd. of rock was used in the shaft work.

The intake shaft area was drilled and grouted from the surface prior to excavation, so as to ensure a water-tight work face.

Immediately on completion of rock excavation, tunnel cleanup was commenced, this being finished by November 15th. The work involved the removal of the ventilation pipe and the other services; the blasting down of tights, and the washing down and cleanup of the invert.

Tunnel Concreting

The concrete lining was placed in three separate stages: first the twin curbs, then the invert and finally the arch. Invert pouring required the use of a long train of equipment and this made progress at the rate of 500 ft. per day. Arch pouring also required an assembly of special equipment to place the concrete by the continuous advancing-slope method. In this system, concrete is pumped through a pipe up behind steel arch forms. The space fills up and the concete, which slumps along the walls to an angle of about 30°, advances in the opposite direction to the pumping motion. The pipe is steadily withdrawn throughout. In this method, concrete is placed about 3 times as fast as in the standard bulkhead system, but is likely to produce a somewhat less dense concrete.

In general, a 6 bag mix was used, as the concrete was required to have a strength of 200 p.s.i. after 12 hr., at which time the forms were removed; also, a liquid type of air-entraining agent was used. To minimize cracking, a continuous water-spraying and fogging operation was used.

Curb pouring commenced about the end of June, 1958 and was completed by November 1st. Invert pouring commenced November 15th and was completed by December 6th, except for a 600 ft. section in the depression area. Arch pouring commenced December 15th, beginning at the intake shaft. A speed of 275 ft. per day was quickly attained and the first 1,400 ft. to the depression area was completed by Christmas.

On pouring the 600 ft. reinforced concrete section in the rock depression zone, progress was quickly slowed down, as it was found that the concrete was not getting up behind the reinforcing bars at the crown and the shoulders. This reinforcing varied in density from 6 in. to 18 in. centres with a clearance between the top of the pipe and the bars of as little as 3 in. in places. Various adjustments were made to the concrete mix, such as using finer stone and a wetter mix, but with little success. Finally, two slick pipes were installed, roughly at 11 o'clock and 1 o'clock on the circle. This proved successful and concrete placement recommenced, the two slick pipes being retained for the remainder of the tunnel. The average rate of progress was 300 ft. per day.

Test drilling in the reinforced section revealed large voids and honeycomb concrete. A large section in this region was subsequently cut down and repoured.

Thirty days after placing, low-pressure grouting was commenced, followed by high-pressure grouting 90 days later. A third and fourth grouting pass was found necessary in the zones of water leakage. Approximately 1 cu. ft. of grout per foot of tunnel was used. A pressure of 50 p.s.i. was used for low-pressure grouting and up to 200 p.s.i. for high-pressure grouting.

Bulkhead forms were used at the intake elbow and at the T-section at the surge shaft, as both these sections were heavily reinforced.

Concreting around that section of penstock extending into the tunnel was done by pouring bulkhead lengths of 80 ft. at a time. Threaded holes were left in the steel plate for grout pipe attachments. Only pressures of up to 35 p.s.i. were used, so as to avoid buckling the liner.

Fig. 4. Placing of one-half of the steel scroll case.

Surge Tank and Penstock

Design of the differential surge tank indicated a 38 ft. diam. outer tank with the top at elevation 1435 and a 12½ ft. inner riser to elevation 1430, with an external 14½ ft. diam. steel liner extending to elevation 1170 in the surge shaft. Location studies indicated a base at elevation 1260, 885 ft. upstream from the unit. Plate thickness of the shell varies from 1-7/16 to ⅜ in.

Erection of the surge tank began about July 1, 1958. The general scheme of erection consisted of welding the shaft liner in 16 ft. sections, lowering them down the shaft and concreting around them subsequently. The internal riser was shipped to the site in complete rings 8 ft. deep. Riser erection was done by using a stiff-legged derrick for the lower rings, and by a jumper pole and jib derrick, attached to the riser, for the upper rings.

The outer shell was formed from semi-circular steel plates, 8 ft. deep, these being welded together in place. Hoisting of these curved plates was done by means of a short mast attached to the top of the inner riser, the latter being previously guyed to the ground.

All welds, both in the shop and in the field, were stress-relieved by the Linde water-spraying method, and were subsequently x-rayed to check their quality. All vertical welds were an x-shaped, double-vee type. Horizontal welds were a k-shaped, double-bevelled variety, these, however, being subsequently ground flush. Low hydrogen rods were used throughout. The shaft liner was completed by mid-August, 1958, at which time the concrete tank base was poured. Work then proceeded on the internal riser, and this was completed by October 1st. Shortly before completion, some local deformation was noted in the lower rings where a bracket footing was attached. This distortion may have been caused by welding. However, as a safety measure against ring buckling, eight 12 ft. vertical stiffener beams were welded inside the riser, one opposite each bracket.

Tank-bottom plates were welded in place and dry packing was done beneath them. Erection of the outer shell was now started and this went on until December 12th, when operations had to stop because of cold weather; by this time, 11 of the 22 rings had been placed.

Steel erection work now commenced on the penstock, beginning with the erection of a stiff-legged derrick on one side of the penstock. Penstock sections were delivered to the site in prefabricated circular pieces about 8 ft. long. All welding consisted of the above-mentioned x-shaped, double-vee type. Those sections immediately adjacent to the powerhouse wall were placed first, and after this, a concrete envelope was poured around them. Penstock work was then suspended for about 5 weeks to permit the removal of tunnel services and track, and final cleanout. About March 20, 1959, a 70 ft. long erection platform was constructed immediately outside the tunnel portal. On this platform, rings for the tunnel section of the penstock were welded into 80 ft. lengths, and thence rolled into the tunnel, positioned carefully and concreted in place. The penstock was finally completed and the surrounding concrete envelope poured by July 1st.

Work on the surge tank shell was resumed about June 1st, this being completed by August 15th, in time for the in-service testing.

Insulation of the surge tank commenced on September 1st. It consists of 3 in. of foam glass in 12 x 18 in. blocks, glued onto the outer shell by an insulmastic vapour seal and supported by a network of vertical rods and horizontal bands welded to the steel shell. This, in turn, is covered by two layers of asphalt glass fabric alternating with a coat of vapour seal for each layer, the whole thing being finally finished off with aluminium paint. The work was completed by winter, apart from the final paint.

Powerhouse

Excavation of the powerhouse site, consisting of 34,000 cu. yd. of rock was begun about April 1, 1958 and completed by October 1st. Line drilling of the penstock cut and the powerhouse outline was done, to confine the overbreak and wall fracturing during blasting operations. A combined tailrace plug and access road was left in place, this being also used for the tunnel railway. Excavated material was disposed of in Little Dog Lake.

A Bailey construction bridge was built across the rear bay of the powerhouse for general hoisting purposes and for concrete pouring operations.

Concreting of the draft-tube began October 1, 1958. The steel draft-tube liner was set in position by December 20th. Shortly after the New Year, the steel scroll case was set in place. It came in two halves, the larger weighing 35 tons. Placing was done by using two 35 ton mobile cranes located on the Bailey bridge; these lifted each scroll section from a float, and set them down on pedestals in the turbine pit. Both halves were temporarily bolted together until final riveting was done. After alignment of the embedded parts, the scroll case was concreted in. By May 1st, work had begun on assembling the turbine parts.

Generator erection began about May 10th, the first process being the stacking of the rotor. Both the superstructure steel and the 175 ton powerhouse crane had been previously erected by about May 1st. The generator stator was made in two halves, each 40 tons. Field poles were attached and keyed to the rotor by June 20th. The stator itself was placed by July 1st, and by July 25th, the shaft, bearing assembly and rotor were in position. By August 10th, the turbine governor piping had been completed and a rotational check on the unit was made.

Tunnel filling, which had to be done quite slowly, was begun on August 22nd. The first rotational check and dryout run were completed by August 26th, and on September 1st, the generator was placed in-service. An excessive runout of 18 mills in the generator shaft was found, when the unit was on load. This was attributed to the floating iron-rim design of the rotor. This was overcome by welding in shims, which eliminated the floating action until an over-speed of 340 r.p.m. was reached.

Intake

Following completion of the intake road, intake excavation commenced October 1, 1957. It consisted of removing 45,000 cu. yd. of earth and 12,000 cu. yd. of rock; this was taken out in the dry behind a natural earth cofferdam, made up of granular glacial material. The excavation invert was 50 ft. below lake level. Rock excavation began about December 1st; a slot, 60 ft. deep, 40 ft. wide and 100 ft. long was cut into a rock hillside. Line drilling was done to limit fracturing of the rock walls when blasting. A certain amount of lake water percolated through the natural cofferdam during this operation, but the volume was well within the pump capacity. Excavation of the elbow behind the intake began May 1, 1958. At the same time, the shaft area was drilled and grouted, since exploratory drilling had shown considerable faulting and doubtful watertightness. Intake concreting began July 1st, and by October, 1958, service gates had been installed in the upstream checks, after which pumping of the cofferdam leakage water was discontinued.

The cable hole for the intake shaft was begun August 1st, by using a 4 in. diamond drill; a previous attempt with an air-track was not successful. Shaft excavation was completed by October 1st and the concreting was done by December 1st.

Intake channel excavation consisted of completing as much dry excavation and surface protection as possible before removing the cofferdam plug. This was followed by wet excavation, using a 10 in. suction dredge. As the material contained a fair number of boulders and was somewhat compacted, difficulty was encountered, and dredging was stopped; the remainder was removed by a 1½ cu. yd. clam, operating from a barge in some 25 ft. of water.

NOTICE

The Seventy-Fourth Annual General Meeting of The Engineering Institute of Canada will be held on Wednesday, May 25, 1960, at the Royal Alexandra Hotel, Winnipeg, Manitoba, between the hours of 10.00 a.m. and Noon. This meeting will receive the report of the official auditors, the Annual Report of Council, Committees, Representatives, and Branches, and such other business as may come before the meeting.

Garnet T. Page, M.E.I.C.
General Secretary

Salient Mechanical Design Aspects of the Selkirk Generating Station

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This paper will be presented at the Annual General Meeting of the Engineering Institute of Canada, Winnipeg, May 1960.

The Selkirk Generating Station is a new thermal plant required by The Manitoba Hydro-Electric Board to meet the steady increase in power demand in the Province. Two 66,000 kw. units are at present being installed and these are programmed to commence commercial operation this year.

This paper deals with mechanical equipment. The civil design aspects of the Station are mentioned only where they affect the layout of mechanical equipment. No reference has been made to the electrical equipment.

The Station site is located approximately 20 miles north of Winnipeg on the east bank of the Red River, opposite the town of Selkirk.

Selection of Site

THE FUNDAMENTAL requirements which have to be met when selecting a site for a coal burning thermal generating station are:

1. Ample water supplies for condensing;
2. Rail and road access facilities;
3. Right of way for transmission lines;
4. Adequate area for coal storage;
5. Means of ash disposal within the general vicinity of the site;
6. Soil conditions suitable for foundations designed to take column loadings of up to 1,000 tons or more;
7. Even terrain, where possible.

The site seleeted for Selkirk Generating Station satisfied all these conditions. Its boundaries are the C.N.R. Pine Falls line to the south-east, Cook's Creek to the east and the Red River to the north and west. The river in fact forms almost half of the site perimeter.

The area of the site is 450 acres thus imposing no restrictions on rail, coal or ashing facilities and allowing ideal planning conditions for development. The average altitude of the site is 738.00 ft. elevation and the normal high water level of the Red River locally is 717 ft. elevation with a normal low of 710 ft.

Planning the Site Layout

From inspection of the site itself and detailed examination of surveys and aerial photographs it became apparent that this site could be a valuable asset to the Board for future developments and offered excellent potential for expansion up to about 1,000 mw. This conclusion formed the basis of the broad aspects of planning, and the locations of the main building, cooling water pumphouse, transmission lines, coal storage area, ash lagoons and water treatment building were established to allow maximum expansion.

Although the present stage of Station development embraces the installation of only 132 mw. of generating capacity, the more detailed planning was based on a plant capacity of 400 mw. A portion of the capital outlay has been made with this in mind and additional plant up to 400 mw. capacity can be installed more economically and the benefits of forward planning realized.

It was considered undesirable to arrange for the cooling water outfall to be discharged directly into the Red River in the vicinity, due to the risk of recirculating warm water during low flow conditions in during the summer months. This possibility has been eliminated by using Cook's Creek as the outfall. Even when the plant is extended to its ultimate capacity the long route of the Creek will provide the necessary cooling effect.

The location of the main building to house the present generating units and any future units which may be installed, together with the location of areas for coal storage and switchyard, etc., are shown on Fig. 1. This key plan indicates the way in which the various components of the generating plant would be allowed to grow. The shape of the coal pile was to some degree influenced by the location of the main building, but the foremost thought in mind was to provide rail facilities which could be developed to handle 250 seventy ton cars per 8 hr. day when the Station reaches its ultimate capacity. The trackage was laid out on the basis that the coal stockpile would be contained within a loop, thus providing for the maximum length of track with the minimum of turnouts in order to simplify car movements. Sufficient length of straight track has been installed prior to the car dumper house to allow the installation of thaw sheds should they be found necessary for winter operation.

The relative locations of the main building, cooling water pumphouse and cooling water outfall are such that the cooling water inlet pipework and discharge tunnel follow the shortest possible routes. The cooling water outfall enters Cook's Creek tangentially at a point where the Creek bends, thus minimising the risk of bank erosion.

Determination of Basement Elevation in Main Building

The boiler house basement is at 740 ft. elevation and the turbine house basement is at 725 ft.

The decision to have a stepped basement which results in differing operating floor levels followed a great deal of investigation. The principal factors which had to be considered before reaching this decision were the cost of building and equipment foundation work and the cost of pumping cooling water through the condensers. The savings which will be realized by the reduced pumping costs with this arrangement more than offset the amount spent on the more complex foundations in the turbine house area.

Main Building Foundations

The conclusion drawn from a report prepared by Professor A. Baracos on the soil conditions was that bearing capacities of 1,500 psf. could be employed in the grey-brown clay 8 ft. and more below grade. This figure gives a factor of safety of about three and is determined from the unconfined compression strengths.

The clays above the 20 ft. depth would undergo large volume changes accompanying soil moisture changes, thus it was considered inadvisable to support structural floors upon the ground. It was recommended that heavy loads should be carried to the hard silt, sand, rock flour, gravel and boulder mixture at approximately 37 ft. below grade level.

To achieve this requirement the foundations are supported on augered cast-in-place "caissons". The minimum diameter of caisson employed was 3 ft. to permit manual excavation of the base to ensure bearing upon the "hardpan". Where exceptionally heavy loads occur the caissons were "belled out" to twice their top diameter to provide additional bearing area. A maximum net safe bearing value of 15,000 p.s.f. was used in the design.

Fig. 2. shows a section through a diamond drill hole which was bored in the turbine house area.

When it was established that the prevailing soil conditions necessitated an air space between the underside of the basement floors and the excavation it was decided to make full use of this for piping and cabling. By routing the piping and the power and control cables associated with the equipment located at the boiler house and turbine house basement levels in the air space, the complex system of floor trenches normally required in a large thermal electric plant was eliminated. This arrangement also enabled cabling and piping installation to be commenced in the subbasement whilst equipment erection was still in progress above. Furthermore, the basement floors were designed, and construction commenced, before all the equipment details were available, thus reducing the time between design and actual construction.

The 54 in. diam. steel pipes conveying the cooling water to the condensers are hung in the air space beneath the building.

To keep the distance between machines to a minimum the cooling water pipes in the turbine room area are contained in a cellular space in the base of the turbo-generator foundations.

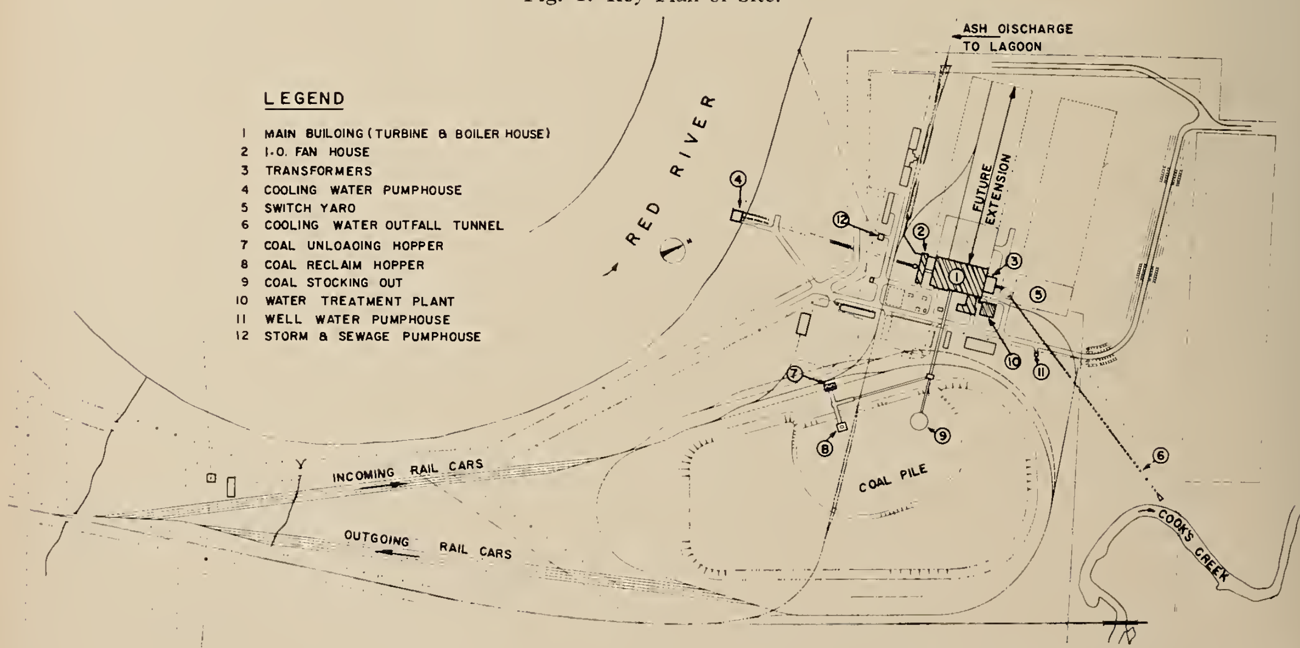
Description of the Cooling Water System

Water from the Red River is admitted to each cooling water pump chamber via a fixed coarse bar screen and a ⅜ in. mesh travelling band screen. The band screens are 10 ft. wide and at 38 ft. centres. A sluice gate is arranged between the fixed and travelling screens to allow isolation of a pump chamber.

The cooling water system is on a unit basis with one set of screens and one pump for each turbo-generator. No provision is made for cross connections.

The level of the intake is at 699.5 ft. elevation, thus providing the screens with a minimum wetted depth of 10 ft. 6 in.

Fig. 1. Key Plan of Site.



The cooling water pumps at present installed are single stage, vertical, mixed flow, propeller type and are each capable of pumping 72,700 US gal. per min. against a head of 36.6 ft.

The winter requirements for the condenser and auxiliary heat exchangers are approximately 36,000 US gal. per min. and to minimize pumping costs the pumps are driven by two-speed (354/237 r.p.m., 900/250 hp.) 4,000 v. vertical squirrel cage induction motors. Each motor has separate high and low speed windings, each winding having its own circuit breaker. The pumps may be run at low speed when the cooling water inlet temperature is less than approximately 45° F.

The discharge from the pumps is below the floor. Each pump has a 54 in. hydraulically operated discharge butterfly valve.

Each pump discharges into a 54 in. steel pipe approximately 1,200 ft. long. The bottoms of the pipes are about 16 ft. below grade level.

An interesting feature of the cooling water system is that the 54 in. pipes pass underneath the chimney foundations. This was done to avoid diverting the route of the pipes as they enter the main building area and thus avoid interference with future extension work. The concrete base slab of the chimney is supported on caissons, and, if necessary, access to the pipes can be had by digging beneath the chimney base without disturbing the chimney foundations.

Each 54 in. pipe terminates in two 42 in. branches, one branch to each half of a condenser. These condenser inlet branches are each fitted with a hand operated butterfly valve. The 36 in. condenser outlet branches are each fitted with electrically operated butterfly valves.

There are rubber expansion bellows between the valves and the condenser on both the inlet and outlet pipes to permit expansion of the condenser, which is supported on helical springs.

The 36 in. outlet branches connect into a 54 in. outfall pipe which terminates in a concrete syphon sealing chamber 150 ft. away from the condensers.

One outfall pipe is provided for each unit. The bell mouth outlet is always sealed by a minimum of 5 ft. of water due to the installation of a weir in the chamber at 715 ft. elevation.

The water flows from the sealing chamber to Cook's Creek via a 7 ft. 6 in. diameter concrete tunnel.

A section through the sealing chamber is shown in Fig. 3.

To ensure release of air from the pipes when the system is being primed, both automatic and manually operated air release valves are installed at the high points.

Due to the height of the syphon in this system and the low temperature of the Red River in winter, it was considered desirable to install vacuum pumps to remove the air coming out of solution at the high points in the system which are above the hydraulic gradient. The high points in the system are piped to a vacuum sealing tank from which the pumps exhaust the air.

There are two vacuum pumps installed to serve Nos. 1 and 2 Units. Each pump is capable of evacuating 240 c.f.m. at 25 in. Hg.

To avoid water hammer in the system which could occur if a pump is tripped out, or fails, anti-vacuum valves of a special design have been installed on the condenser outlet pipes. Thus, if the water column separates at the point of low pressure, air is admitted in sufficient quantity to prevent rejoining of the columns.

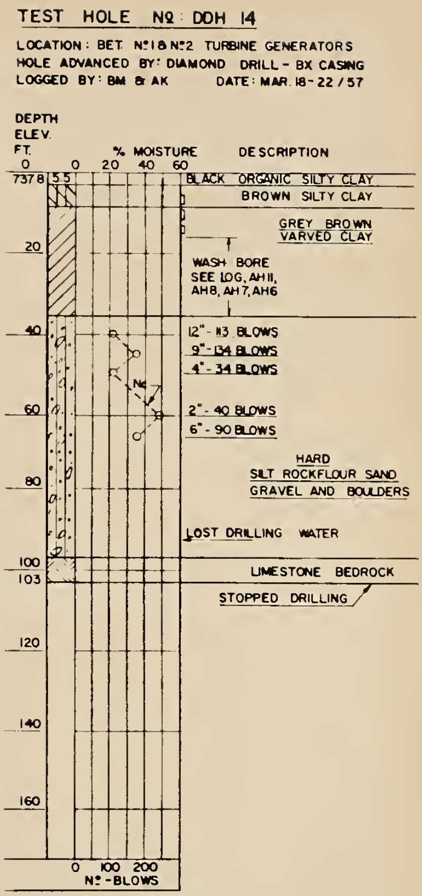


Fig. 2. Typical Soil Boring in Vicinity of Main Building.

Coal Handling Equipment

South Souris lignite coal, unscreened and crushed to minus 2 in., is delivered to the Station in 70 ton nominal capacity, gondola type, railroad cars and discharged to an underground coal dump pocket to enter the coal handling system.

The flow of railway traffic is shown on Fig. 1. This arrangement provides an efficient flow pattern for incoming loaded cars and after discharge at the dumper house cars continue round the loop to be finally marshalled on the outgoing siding.

Unloading of cars while the Station capacity remains at 132 mw. will be assisted by a coal car shakeout. The rate of coaling during this period will not exceed 400 tons per hr. At a future date, however, should the Station be extended, the shakeout will be replaced by a rotary car dumper. Provision has been made in the design of the dump pocket so that a rotary dumper of any existing type can be fitted with the minimum of inconvenience. To match this increased unloading rate, all conveyor equipment can be boosted to handle 800 tons per hr. by the substitution of larger motors and drive couplings and by changing chain drive sprockets on the conveyors.

The system of conveyors is such that coal emptied into the car unloading hopper can be taken to the coal bunkers in the main building after passing through the coal crushers in the crusher house, or delivered to the Station stockpile. When withdrawing coal from stock it must be dumped into the reclaim hopper by scraper or bulldozer where it enters the conveyor system for crushing and transfer to the Station coal bunkers.

The car unloading hopper and the reclaim hopper are fitted with reciprocating feeders and vibrating feeders respectively to ensure an even flow of coal on to the conveyor belts.

Upon commencement of a coaling operation the conveyors, feeders and crushers are started in sequence and tripping of any item will shut down all preceding equipment in sequence. A pushbutton local to all major equipment must be depressed by a roving operator before the system can be started from the coal plant control panel. A personnel protection system in the form of a fail safe emergency trip cable is furnished alongside all conveyors. All equipment is stopped and an alarm is initiated if this cable is pulled. Control circuits must be key reset before equipment can be restarted.

An outstanding feature of the Selkirk Station is the design of the coal bunkers. Each of the four bunkers is an independent container, comprising a 31 ft. diam. and 39 ft. high vertical cylindrical section mounted above twin discharge cones each feeding a pulverising mill. Each bunker when fully charged will hold 725 tons of coal and with all bunkers full the two units could operate at maximum rating for 24 hrs. with the coal plant out of service.

It is considered that there are certain distinct advantages to be gained by adopting the silo type of bunker arrangement in preference to the more conventional rectangular design. The foremost of these is that due to the absence of corners, flow characteristics are improved. There is also a saving in the quantity of steel involved to give the same storage capacity. The silo type of bunker can more readily be sealed against dust and air leakage. These advantages are to some extent offset by additional field steel erection costs.

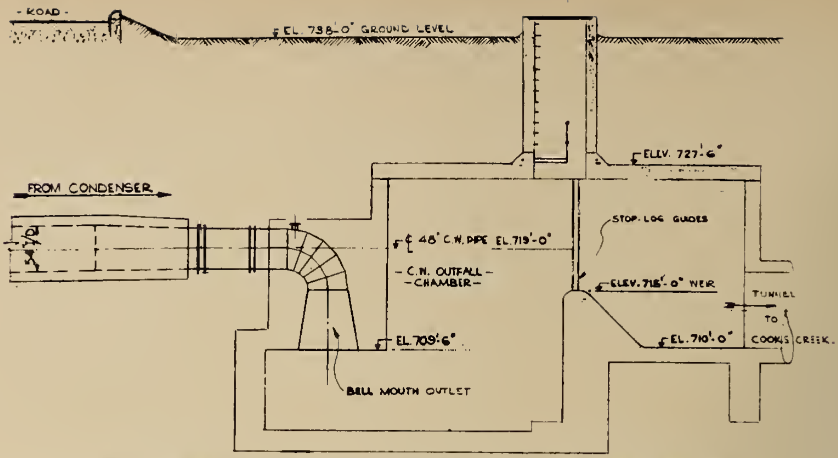


Fig. 3. Section through Cooling Water System Sealing Chamber.

Water Supplies and Methods of Treatment

Considerable quantities of water are required in the operation of a thermal generating station. For many of the varied services for which water is used quality is a prime consideration.

As in the preliminary studies for all generating stations, considerable research time was spent before deciding on the source of water and method of treatment for each system at Selkirk. The choice open for source of water in this case was limited to the Red River or subterranean waters beneath the Station site.

Analyses were available of the Red River water and study of these, in conjunction with samples taken during the investigation period, indicated that this water would require a high degree of clarification before it could be processed by either deionisation or evaporation. Efforts were then concentrated on obtaining the maximum information available on the aquifer.

Local well owners were approached and data obtained on quality and drawdown indicated that tests on the Site would be justified. The outcome of these tests is that there are now two wells sunk to a depth of 140 ft. from which two 5-stage bowl pumps can each deliver 500 US gal. per min. to cater for boiler feed, general service and domestic water requirements.

All water discharged from the deep wells is injected with 2 p.p.m. of chlorine for the purpose of killing any trace of bacteria. It is then piped to the water treatment building (See Fig. 5) where it is passed through a coke tray aerator to oxidise any soluble iron present. The water is then divided into two streams, one of these being destined for boiler feed make-up, the other for general water services and domestic supplies.

The boiler feed make-up which can be processed at a rate of 60 US gal. per min. passes through three separate stages of treatment before reaching the desired standard of purity. The first of these stages consists of partial softening with lime in an 11 ft. diam. reactor. This treatment reduces the alkinity, hardness and dissolved solids content and simultaneously coagulates and removes any organic matter present. Water from the reactor is passed to a clearwell from which it is pumped as required through two anthracite filters. This is followed by a second filtration through a carbon filter to remove chlorine and any remaining traces of organic matter that may have escaped coagulation.

Effluent from the filters is piped to the demineralisation units where silica and dissolved solids are almost completely removed.

The demineralising plant consists of two separate banks, each bank having one 3 ft. 6 in. diam. cation unit, one 3 ft. 6 in. diam. anion unit and one 3 ft. diam. mixed bed unit. In service, each bank is regenerated alternately, using common regerant pumping and storage facilities. The regeneration proceeds automatically after unit selection and initiation by the operator.

Chemical effluent from the demineraliser units during the regeneration cycle is directed to a collecting tank located in the basement of the water treatment building. This lined mild steel tank which will hold the waste products from one complete regeneration cycle, or a quantity in excess of 11,000 US. gal. plus approximately 1,000 gal. of lime slurry blown down from the reactor, is equipped with a slow speed agitator to retain solids in suspension. These wastes are pumped by one of two stainless steel pumps via an asbestos-cement pipeline to the ash disposal lagoon.

All feed make-up water leaving the demineralisers is fed directly to the condensers. Due to the corrosive nature of this ultra pure water, polyethylene piping is used for this service. The water is introduced into the top of each condenser via a stainless steel spray nozzle so that it can be broken down into small particles and its dissolved oxygen content effectively reduced by the condenser air ejectors.

The second stream leaving the aerator, that for general services and domestic requirements, is far greater than that for feed water make-up and is of the order of 350 US gal. per min. By pumps taking their suction from the aerator clearwell the water is passed through three 6 ft. diam. sand and gravel filters which remove iron precipitates from the water. The filters discharge to a concrete reservoir built into the foundations of the water treatment building. The maximum capacity of this reservoir is 44,000 US. gal. and it acts as an extension to the water storage facilities in the main station building. Pumps controlled by level switches in a high level general service water tank located centrally in the main building take their suction from this reservoir and deliver water to the high level tank for distribution to the many items of equipment in the Station requiring cooling water.

Water for drinking purposes and

other domestic uses is tapped off the main supply line to the high level general service tank and further processed before entering a 1,500 US. gal. storage tank. The treatment given to this water comprises a minimum of one hour's retention in a small tank while being dosed with a 1% solution of sodium hypochlorite. It is drawn from this tank by a booster pump to be passed through a carbon filter to remove all traces of odour and taste picked up in the preceding treatment and then through a base exchange softener before finally reaching storage.

Water Storage Facilities

Reference has already been made to some of the provisions for the storage of water, therefore this section will deal briefly with another aspect of the water storage problem in a power station.

Great care has to be exercised in the proper selection of lining materials for tanks and pipework. As in the selection of all materials and equipment, economics play an important role in the choice of linings; whereas if cost were of no consideration, most of the pipework and tanks would be given a liberal lining of rubber, some less experience substitute has to be found in most instances.

In the case of the feed water storage vessels, this substitute takes the form of vinyl plastic. This material will have no harmful effects on the demineralised water in storage and is expected to maintain complete separation between the water and the steel tank, without maintenance, for well over five years. The vinyl plastic is sprayed on to a thickness of 25 mils after the tank interior has been sandblasted and forms a cocoon over all steel parts.

The collecting tank for water treatment wastes is also lined with a sprayed-on vinyl cocoon and in this case the lining material has to protect the tank from attack by a mixture of dilute sulphuric acid, dilute caustic soda and lime slurry. Again no maintenance is anticipated during the first 5 years of operation.

The domestic water tank and the general service water tank are treated internally with special paints. After the internal surfaces have been prepared by wire brushing a coat of metal primer is applied, followed by two final coats of a gilsonite base preparation. Length of life and ability to prevent odour and taste being imparted to the water are essental properties of this coating.

Vessels receiving high temperature drains and boiler blowdown receive no internal treatment.

Steam Generators and Ancillary Equipment

The two boilers are each designed for a continuous capacity of 600,000 lb. per hr. of steam and a 4 hr. peak load of 625,000 lb. per hr. The steam condition at the superheater outlet at these ratings is 875 p.s.i.g. and 915° F.

The single pass furnace of the boiler units is completely water-cooled and employs natural circulation. There are two drums per unit, one 72 in. diam. and the other 48 in. diam. The steam drum, which is the larger of the two, is equipped with cyclone steam separators with a collecting manifold and steam scrubber baffles.

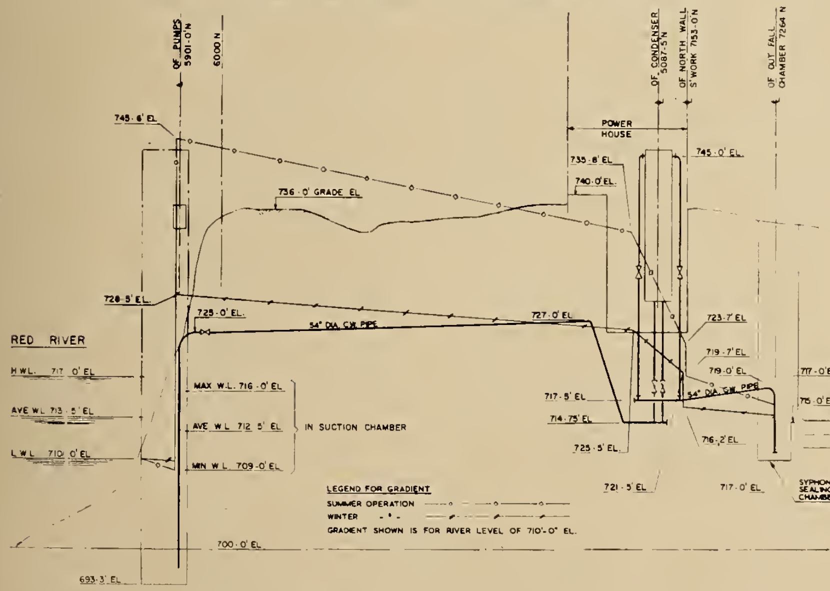


Fig. 4. Hydraulic Gradient for Cooling Water System.

The superheaters are of the radiant type arranged to be fully drainable. Between the primary and secondary sections of the superheaters a submerged surface-type attemperator is located to give fine control on steam temperature. The desired superheater temperature can be automatically maintained over a load range of 90,000 to 625,000 lb. per hr. of steam.

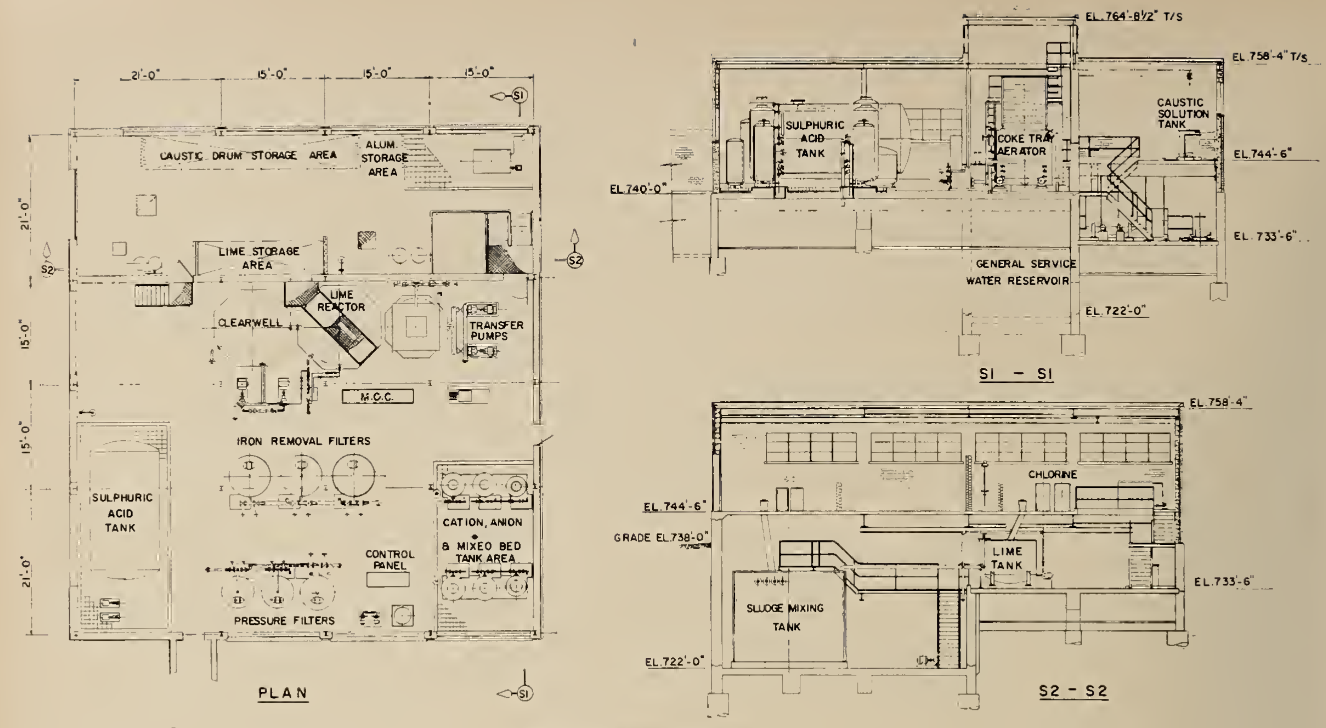
The boiler bank and superheater tubes are furnished with electrically operated retractable type steam sootblowers arranged for automatic sequential control from the plant control room.

The four pulverisers per unit each serve three circular coal burners distributed across the front wall of the furnace in 4 rows of three. An automatic electrically-operated igniter operating on No. 2 fuel oil is provided for each burner. The burner lighters are of the mechanical atomising type and twelve of them are capable of maintaining a steaming rate of more than 90,000 lb. per hr. The burner impellers, air registers, igniters and coal/air valves are all power operated and controlled from the plant control room.

The two forced draft fans and the two induced draft fans per unit are driven through hydraulic couplings. The forced draft fans are fitted with variable inlet vanes and the induced draft fans with adjustable multi-leaf inlet dampers.

At very low loads air flow through the forced draft fans and gas flow through the induced draft fans is controlled by remotely positioning the inlet vanes and dampers respectively. Upon increase in load the inlet vanes and dampers will be fully opened and flows will be varied by means of the hydraulic couplings.

There are two regenerative type air heaters per unit. Each air heater is fitted with a cleaning device for steam or air blowing. The cleaning operation can be controlled manually, or automatically, in sequence with the main furnace sootblowers, from the sootblower panel in the plant control room. Air or steam can be selected as the blowing medium by a switch on the sootblower panel. Air will be used when steam is not available during start-up. A high pressure off-load, water washing system is also provided for each air heater. During the washing operation the air heater rotor speed has to be reduced. This is achieved by means of an air driven motor which can be engaged to the rotor drive speed reducer by manually operating a clutch lever. During the washing operation the water after passing



WATER TREATMENT PLANT

Fig. 5.

through the air heater elements is collected in a hopper below the discharge gas duct and drained to waste.

Two tubular type dust collectors with an anticipated collection efficiency of 89.1% remove suspended solids from the gas stream.

Ash and Dust Equipment

Furnace ash is collected in a wet hopper located below the boiler. It is discharged as a water-ash mixture through a clinker crusher and passed to the ash lagoon with the assistance of a venturi type jet propulsion pump. The 9 in. diam. pipework between the main building and the ash lagoon is approximately 1,300 ft. in length and is of cast alloy material. It is arranged so that it can be turned periodically to allow an even amount of wear to take place on the pipe wall.

During operation of both steam generator units it will take about 35 min. to empty their two ash hoppers. After all bottom ash has been manually discharged, fly ash is automatically withdrawn from the collection points of both units. This is done in sequence, from first one unit and then the other at a rate of 20 tons per hr. The fly ash system will operate for approximately 12¾ hrs. in every 24 hr. to remove the dust accumulation from two units operating continuously at MCR. Fly ash accumulated in the mechanical dust collector hoppers, air heater hoppers, high level hoppers in the gas ductwork, furnace rear pass hoppers, stack hoppers and the vacuum cleaning plant dust storage bin is withdrawn in a dry state through a water jet exhauster where it is mixed with water. It then passes through an air separator, which vents entrained air to atmosphere, and the mixture of dust and water then flows by gravity through the ash discharge pipework to the lagoon.

Turbo-Generators

Each turbo-generator unit is capable of a continuous maximum rating of 66,000 kw. The turbine is of the impulse reaction type consisting of 2 cylinders on a single shaft directly coupled to a hydrogen-cooled alternator.

Bleed points from the turbine supply steam to 5 stages of feed water heating. The third stage heater takes the form of a high level deaerator.

Each machine has its own independent motor driven exciter set.

Turbine House Crane

The turbine house is equipped with a loading bay and a 150 ton overhead crane. This crane is sized to lift the heaviest piece of equipment of a 100/120 mw. machine and will, therefore, save installing of a further crane if a machine up to this size is called for in the future.

Plant Control

Both boiler-turbine units are controlled from a central plant control room. This room is located at the boiler operating floor level and overlooks the operating floor of the turbine room.

It is anticipated that 3 control room operators and 2 roving external operators will be required each shift. The roving operators will carry out specific local operations during start-up and shut-down of the machines and will maintain contact with the control room operators by means of a PAX and voice paging system.

Although boiler light-off and loading will be carried out from the control room, the control room operator will rely on the external operator for assessment of flame conditions.

Automatic means are provided to maintain constant steam temperature, to control feedwater flow to the boiler and to control the fuel/air supply to the furnace.

Steam after leaving the drum passes through a 2-stage superheater. To provide a means of controlling final steam temperature, a three-way valve in the primary superheater outlet can be positioned to control the amount of steam delivered to a drum type attemperator. The cooled steam is then mixed with the main supply before entering the secondary superheater.

A resistance type sensing device measures steam temperature leaving the secondary superheater. The output from an electronic controller is converted to a pneumatic signal to operate the air cylinder positioner on the three-way valve. To improve system response, steam flow is utilised to produce an anticipating signal.

Feedwater flow to the boiler drum is controlled by changing the feed pump speed. There are two 100% boiler feed pumps and each is driven by an electric motor through a hydraulic coupling. There is no feedwater regulating valve.

Boiler drum level acts as the final feed flow control element but signals from the steam and feedwater flow transmitters are utilized to give a 3-element control system.

A steam pressure-steam flow two-element control system (steam pressure being the master) automatically controls fuel and air into the boiler to maintain steam pressure constant at the superheater outlet.

The amount of fuel delivered by the pulveriser is varied by controlling the amount of primary air passed through the mill by the associated P.A. Fan. This is done by pneumatically positioning the P.A. fan discharge damper. A 2 speed coal feeder motor automatically adjusts the amount of coal fed to the pulveriser and maintains coal bed thickness in proper relation to primary air flow.

Combustion Air and Station Heating Systems

The ventilation and combustion air supply system is designed on a unit basis. There is one boiler house plenum chamber and one turbine house plenum chamber for each generating unit, each with its own air intakes, coil face and bypass dampers, heating coils, fans and discharge ducts.

The boiler house plenum fans draw outside air through the heating coils and discharge into the boiler house area near the forced draft fan suctions. The face and bypass dampers in the plenum chamber are arranged to modulate so as to maintain a selected air temperature in the discharge duct to the boiler house. Control of dampers is carried out by means of duct mounted thermostats.

The turbine house plenum fans deliver air to the turbine house via distribution ducts located in the roof trusses. This air ultimately passes through louvres provided in the partition wall between boiler house and turbine house. Upon entering the boiler house a portion of the air is taken by the forced draft fans for combustion purposes. The remainder passes upwards, providing a means of ventilation, and is eventually drawn off and recirculated by the turbine house plenum fans. The air used for combustion is replaced by drawing outside air through the face and bypass dampers and the heating coils. The dampers in the turbine house plenum chamber are arranged to modulate to maintain a selected air temperature in the discharge duct to the turbine house.

Coil heating in the plenum chambers and space heating in the main building and water treatment building is accomplished by 100 p.s.i.g. steam. Steam from the same system but reduced to 15 p.s.i.g. is used for heating purposes in the administration wing.

The method of distributing heat in the general working areas is by use of finned radiation and unit heaters. Fin strip radiators are located around the main building walls in roughly two tiers. The upper tier is controlled at various points by thermostats actuating on-off control valves so that these heaters are brought into service as demanded by temperature level. The lower tier can be controlled by hand as desired. Unit heaters are located at all outside doors and at other selected points throughout the Station. Operation of these unit heaters is by means of local thermostats providing on-off control of the fan motors. Thermostatically controlled unit heaters are the sole means of maintaining temperature in the water treatment building and induced draft fan house. The administration wing offices are served by finned radiation and the workshop area by unit heaters.

Steam for all heating services is available from three sources. A package type water tube boiler arranged to fire No. 2 fuel oil and to produce 20,000 lb. of saturated steam per hour at 100 p.s.i.g. is the basic source of supply. This boiler will be used to provide heating steam during off-load periods in the Station and also for combustion air heating during initial start-up of the main station generator units.

The other means of providing heating steam is from the two main steam generator units via pressure reducing and de-superheating equipment. When sufficient steam is available from either or both of these sources, the auxiliary boiler will be shut down.

All condensate from the heating system is led back to the reserve feed water tanks. The arrangement of this system is such that condensate is returned to the tank associated with the unit from which the steam was taken. During operation of the auxiliary boiler, feed water is drawn from either feed water tank and condensate is returned to the same tank.

Outlying buildings at the site are equipped with their own heating systems. The cooling water pumphouse is heated by an oil fired hot air space heater coupled to a system of distribution ducts. Besides heating the general pumphouse area, the hot air is also discharged into the cooling water screen chambers for de-icing purposes. The coal crusher house is heated and ventilated by a hot air ducted system, utilizing return air plus a portion of filtered outside air. Heating is carried out by electrical coils. This system pressurizes the crusher house areas containing electrical and control equipment and also the locker room and shower stall, thus preventing the ingress of coal dust.

The plant control room and telecommunications room are served by a 12 ton package type air conditioning unit, using fresh and return air delivered through a duct distribution system located in the ceiling of these rooms. The unit incorporates a steam heating coil for air tempering purposes.

Exhaust fans are provided in the main building, induced draft fan house and water treatment building for use during the summer months.

Piping Materials and Construction

In selecting materials to be used for the main steam and feed pipework, temperature is the main criterion. Since the superheater outlet steam temperature at Selkirk will be 915° F., a 1¼% chrome, ½% molybdenum alloy was selected for the main steam pipework. If a plain carbon or even a carbon-molybdenum steel were used for this service, there would be a distinct risk of graphitisation taking place. The presence of chromium in the piping material tends to have a stabilising effect and inhibits the formation of graphite at elevated temperatures. The use of this material extends to auxiliary steam pipework and to all fittings and valves which will be subject to main steam temperature.

The final feedwater temperature of 400° F. is well inside the limit for use of carbon steel materials, and apart from the necessity for heavy wall piping on the discharge side of the boiler feed pumps, the feed pipework is to ASTM A.53 specification.

Butt welded joints are employed practically throughout the various piping systems and all shop and field joints in the steam mains are made by an inert gas welding process.

Application of Microwave Radio Links

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This paper will be presented at the Annual General Meeting of the Engineering Institute of Canada, Winnipeg, May 1960.

Microwave radio-relay systems have played an increasingly important role in recent years in the provision of large quantities of high-grade communication circuits. Systems can be categorized as "heavy route" or "light route" depending on circuit requirements and distances involved between terminal points. Careful route layout is required in order to use the minimum number of repeaters necessary to provide the desired performance and reliability.

The requirement for a system is created by the demand for more circuits or the improvement of existing circuits. Once a requirement has been established, the most suitable route must be determined. If the end points of the system are widely separated and intermediate requirements are not of major proportions, considerable savings can accrue with wise routing. An actual case will be used to demonstrate this approach to routing. Sometimes special cases create the demand for a microwave system. A case will be described in detail where a complete toll line was replaced by a microwave system without circuit additions.

For a proposed system, the required performance must be established with consideration for the ultimate capacity of the route. The system must then be engineered to these requirements. Cost and propagation studies must be made and the technical and service features of available equipment must be investigated to determine the best means of meeting the requirements. This paper details the calculation and considerations for performance and reliability necessary to engineer a light route system for a typical case. Performance figures based on actual results are presented. Systems using both frequency and space diversity to maintain propagation reliability are described.

THIS IS an age when good communication with our fellow man is of more concern than ever before. It is a continuing search for the goal of perfect communication that has led to vast networks all over the world for the sole purpose of passing information immediately from one person or machine at one location to another over vast distances.

Possibly the greatest single contributor to this and future realizations is the application of the microwave spectrum and associated technique to serve as the carrier of information. During the past decade, the use of microwave systems has become the means of transmitting large numbers of high-quality voice circuits as well as television pictures and data information over distances of thousands of miles. Microwave is also coming into wider use for short-haul facilities over distances of the order of 100 miles or so. It is the intention of this paper to outline considerations for the use of microwave in the short-haul field, from the point of view and the experience of an operating common carrier which has been using microwave for just this application for some thirteen years.

The use of microwave has developed to a high degree because of necessity. A bandwidth of several megacycles is required for the transmission of television pictures and large groups of voice circuits. The microwave spectrum is the only source of bandwidth capable of satisfying the requirements. Thus the state of the microwave art has developed to the degree that systems can be engineered with reliability and performance characteristics equal to or better than those of other facilities. The width of the baseband which carries the information on a microwave system is only a small percentage of the operating frequency. Because of the nature of microwave frequencies, the energy from a transmitter can be maintained within a prescribed area, so that the same frequencies can be used in adjacent areas without interference. There is, of course, a practical limit to the spectrum space available for efficient usage, but this limit is expanding day by day in research laboratories and field installations.

The manufacturers of microwave equipment are continually improving their product so that there is suitable equipment to do a given communication job, be it thousands of circuits over thousands of miles in one extreme, or dozens of circuits over hundreds of miles or less in the other extreme. Reliability of materials used has improved, and more is known about system behaviour. The use of the microwave spectrum has become so wide that regulatory bodies find an increasing problem in their administration of the spectrum.

Frequency assignments must be made on a coordinated basis for maximum efficiency in use of the spectrum, and the greatest benefit to all users. Even though the energy from a microwave transmitter can be maintained within a certain area, this is only in degree, and each case must be considered on its own. This applies stringent requirements on the user to ensure that a proposed system will not interfere with another system or that some other system will not interfere with his. The ultimate capacity of a route within a given frequency band, the type of antenna, the transmitter power and output spectrum, receiver sensitivity and selectivity as well as geographical proximity are factors involved in interference considerations. Users must comply with the Radio Act. In Canada it is the Minister of Transport who administers this act. Those who contemplate the use of microwave equipment must have approval of the Department of Transport before such a system may be placed in service.

A need must be established before a microwave system is planned. Since it may be possible to provide facilities by some other means, such as cable or open wire, these facilities must also be investigated. This is particularly true in the case of light route systems. The basic requirements are established by demand for new or additional facilities, or replacement of old facilities. Sometimes this requirement may come about as the result of natural growth, or it may arise for other reasons such as storm damage, rapid unexpected economic growth in an area or for defence requirements. The number and quality of the circuits required is a major consideration since the ultimate choice of equipment to be used will depend to a large extent on this. There is no point in establishing a high-capacity system, using equipment capable of long-haul circuits. Cost studies considering capital investment and annual carrying charges must be carried out.

The location of the terminals will be determined by requirement for facilities, but the location of repeaters between terminals will be determined by factors which have no direct relationship to the requirement for facilities. If there are requirements at other locations between the end terminals, this will, of course, influence the route. In general, a repeater will be required on an average of every 25-30 miles between terminals. The repeater must be self-contained and capable of operating continuously for weeks or even months without being revisited. This means that standby power equipment must be provided as part of the repeater which must be capable of carrying the station load. The site should be accessible from travelled highways and should be as close to a maintenance centre as practical. In systems in use today in most applications, interruptions of a few milliseconds cannot be tolerated, thus it is necessary to provide a protection channel and a source of power which will not be interrupted for even an instant.

The actual location of a repeater station is usually proposed as the result of map studies. Following this the site must be visited to ascertain actual conditions and a propagation survey is usually carried out to confirm intermediate elevations, calculated clearances and required antenna heights. Features of the paths between repeaters which require special consideration are usually obvious from maps and profiles drawn from maps. These features may be such things as large bodies of water or flat land which may or may not require special treatment

On average paths sufficient clearance of the direct ray over intervening obstacles must be provided. The necessary clearance over a given obstruction is a function of the wave length of the frequency used, the length of the path and distance of the obstruction from the ends of the path. The radius of the fresnel zone at the point of obstruction must be determined and the amount of clearance in percentage of fresnel zone can be specified. The first fresnel zone radius is calculated in accordance with the following formula:—

$$R_1^2 = \frac{\lambda d_1 d_2}{d}$$

Where all quantities are expressed in the same units.

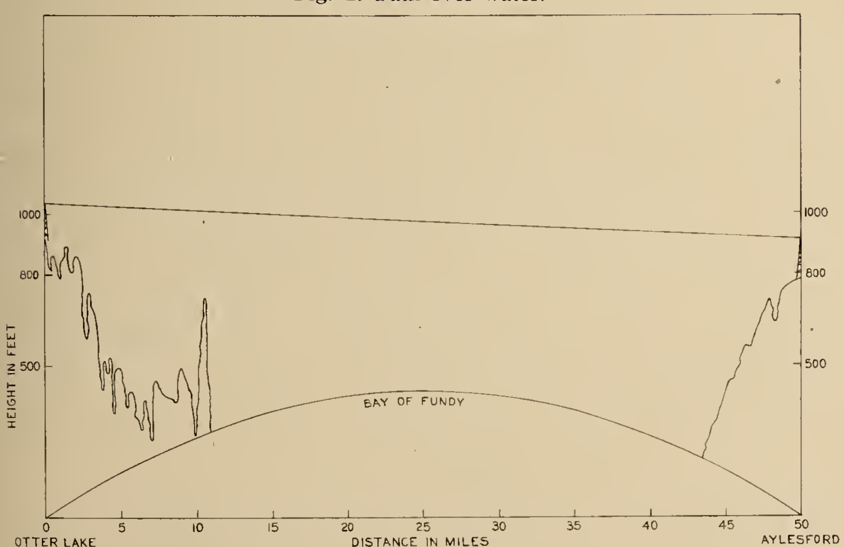
In simplified form

$$R_1 = 72\left[\frac{d_1 \times d_2}{d \times F}\right]^{1/2}$$

Where $d_1 + d_2 = d$ and F is the frequency in thousands of m.c.s. If a profile of the proposed path is drawn on true earth profile paper, 0.6 of first fresnel zone clearance should be provided. This has been found to provide sufficient margin on average paths over rough terrain.

In the case of a path over water such as shown in Fig. 1 special treatment is necessary. Paths of this type are particularly susceptible to fading due to interference of the direct and reflected rays. This is known as fresnel type fading and is severe when the point of reflection falls on a good reflecting surface with a phase shift of 180° on reflection. If natural obstructions can be used to block the reflected ray, the effect of fresnel type fading can be reduced. Such a path is shown in Fig. 2. If however, blocking of the reflected rays cannot be achieved, a form of diversity reception must be used. This may take the form of vertical space diversity or frequency diversity. Paths using both types at different frequencies are described in this presentation. Fig. 3 shows the relative performance to be expected with Rayleigh distribution fading on non-diversity circuits and those using frequency diversity.

Fig. 1. Path over water.



Tests have been conducted on over water paths which showed that fresnel type fading of the order of 40-45 db. was common and that coefficients of reflection were as high as 90%. Fades can be overcome by the use of extremely high power transmitters, but this is generally not economical nor is the predictable improvement sufficient to warrant the high cost. Vertical space diversity has been used with a great deal of success. Space diversity will generally maintain the circuit within limits but it is maintained by others that it will not completely eliminate fresnel type fades, since the lobe size varies during the fading period and correlation of fading does not exist at the antennae. Normal dual diversity is used but in severe cases triple space diversity will fill in most of the gaps left by dual space diversity.

By placing the third antenna ½ Svd above or below the other two antennae complementary diversity is secured over a range of ½ to 1½ times Svd. (Where Svd is the calculated vertical spacing for fully complementary diversity.) Svd can be determined in the following manner:

The spacing should provide approximately a $\lambda/2$ variation between the geometrical path difference in the two cases. The spacing in feet for d in miles, h in feet and λ in centimetres and f in megacycles is given by

$$\text{spacing} = 43.4\lambda d/h$$

Where h is the height of the transmitting antenna above a plane drawn tangent to the point of reflection.

Frequency diversity provides the most reliable protection against fresnel type fading since transmitters and receivers usually use common antenna and the protection equipment is diplexed with the regular equipment so that exact correlation is maintained at both frequencies. Using this method the amount of signal received by one receiver when the other receiver is in fade can be predicted as a function of the path and frequency difference. Tests by others have shown that frequencies

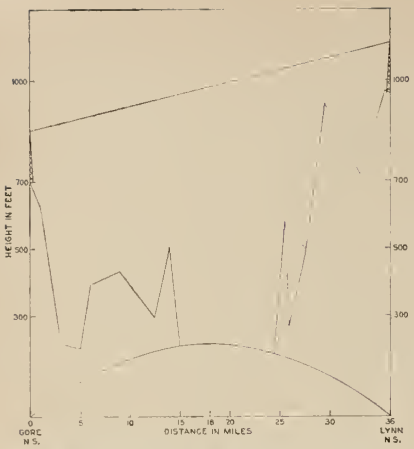


Fig. 2. Fresnel type fading reduced by blocking of the reflected rays.

differing by 4 to 8% are required for frequency diversity. Thus it seems that at microwave frequencies, frequency diversity is perhaps the most reliable means of maintaining propagation reliability and since higher microwave frequencies become easier to control as to where they go, the use of additional frequencies for this purpose would not be so likely to limit other systems in the same area as would more likely be the case with high power transmitters. A further major argument for the use of frequency diversity is that a highly reliable form of protection is provided for the regular channel and one channel is available for maintenance and routines which are absolutely necessary to the provision of highest reliability.

Once the paths of a system have been established as satisfactory and antenna heights have been determined for the frequency band to be used, the performance requirements must be considered. If frequency diversity is to be used, the diversity equipment will also perform the function of equipment protection in case of component failure. Hot standby equipment on the same frequency may be used, but even on light routes this is not too good a method since an interruption can occur on switchover. Thus even for equipment protection, a frequency diversity system with diversity combiners or microsecond switches offers the best solution.

The degree of reliability is represented by the ability of the system to provide uninterrupted service. Reliability is thought of in terms of propagation reliability and equipment reliability. In well designed systems, the degree of reliability can be in excess of 99.99% which is relatively few minutes outage in a year.

The performance of a microwave system is measured by its ability to maintain a good ratio of signal to noise over a long period. Noise includes crosstalk, which arises as the result of intermodulation in non-linear elements of the system and will appear as babble on circuits operating over the system. The receiver noise figure, path losses between transmitter and receiver, the transmitter modulation characteristics and the type of antenna and transmission lines are the most important factors in determining noise performance of a system. The effect of these factors is either known or can be calculated for a specific case so that the performance to be expected of a system is predictable. In calculating the performance characteristics of a system, care must be taken that sufficient margin is provided to care for variations in path loss due to fading, and that a maintenance margin is provided. No piece of electronic equipment in the field will maintain its peak performance indefinitely. Components and vacuum tubes are bound to deteriorate. These variations in performance show up as a deterioration in system performance, and therefore must be carefully considered in the system design.

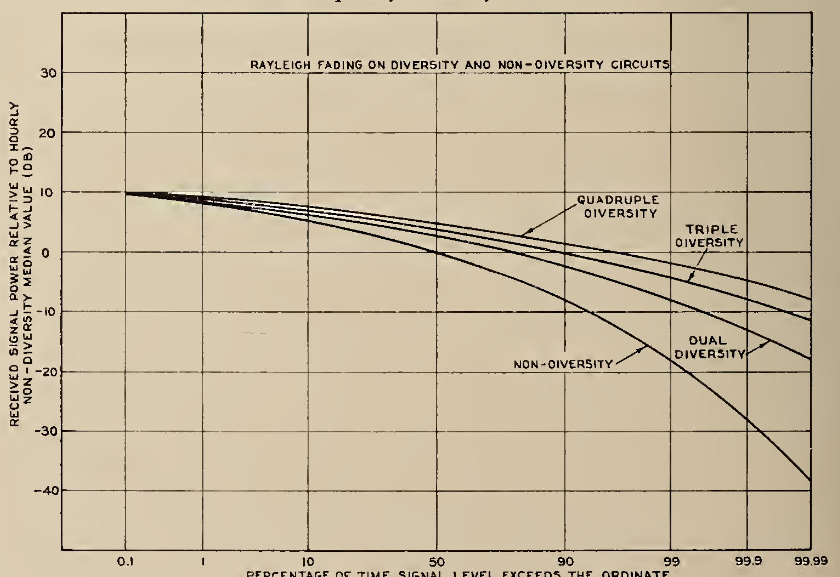
The mechanics of measuring the actual performance of broad band microwave systems has been somewhat simplified recently by the introduction of white noise tests sets. These sets can be used to load a broad band facility at the transmitting end with noise which represents the full complement of circuits. The equivalent space of one circuit is not occupied at the transmitting end, and the amount of noise received at the far end in the corresponding unoccupied space provides a rapid means of checking intermodulation performance.

Maintenance considerations are of prime importance in the establishment of a microwave system. The mechanical layout of the equipment, similarity to other equipment familiar to the user, and the quality of components used in circuitry, all affect the maintenance of the system. A maintenance margin as mentioned above should be provided. The quality of instruction books provided with a given equipment is one of the largest single factors in determining the quality of maintenance, since equipment failures, mainly vacuum tubes, are the source of most outages in a well engineered system. Good maintenance may be taken for granted, but in the end it is the maintenance man on a system, whose efficiency will determine the system performance and reliability once it is installed, and he must have the right information and tools for the job.

In choosing the equipment for a system, there are many sources of satisfactory equipment, and it is up to the system design engineer to determine which equipment is best suited for a particular job. All available information should be reviewed and if at all possible, working systems of the same type equipment should be visited for first-hand information.

A good alarm system is an important part of any microwave system. Since repeater stations are normally unattended, it is essential that information be passed to an attended location, as to whether or not abnormal conditions exist at a repeater. The scope of an alarm system might range all the way from a simple station alarm which indicates yes or no, to a complex system which can check many conditions and give a qualita-

Fig. 3. Relative performance with Rayleigh distribution fading on non-diversity and frequency diversity circuits.



tive report. Part of the alarm system should contain control functions so that the switches may be controlled remotely for such functions as exercising the emergency power equipment. The importance of a reliable alarm system cannot be over-emphasized, and the provision of a reliable alarm system either over the microwave system itself or over other facilities warrants major consideration in system design.

The major items to be considered in the establishment of a repeater on a microwave system once the sites have been determined are:—

- Building
- Radio Equipment
- Emergency Power Equipment
- Tower
- Antenna
- R. F. Transmission Lines
- Test Equipment

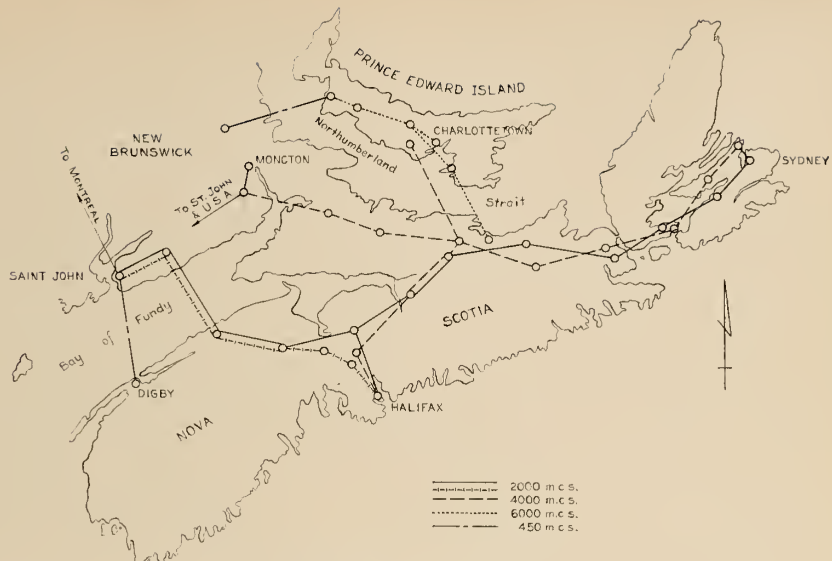
If each of these is thoroughly investigated and properly installed, operating problems will be a minimum.

The process from ordering of the various equipments to the establishment of a reliable system with the desired performance characteristics should be a smooth coordinated flow of accomplishment with realistic target dates.

Before a system is cut over for service, the user should ensure that each piece of equipment meets its own performance requirements and that the system as a whole is satisfactorily integrated. Following cutover to service, a long-term analysis should be conducted to ascertain that the system lives up to the calculated reliability and performance characteristics.

Despite the low population densities, the geography of the Maritime Provinces has brought about a high concentration of microwave equipment in that area and even further expansion is already in progress, with more in the planning stage. As shown in Fig. 4, the Northumberland Strait separates Prince Edward Island from Nova Scotia and New Brunswick, and the Bay of Fundy reaches inland across a direct route between the larger centres of population at Halifax and Saint John.

In 1947 one of the earliest commercial applications of microwave on this continent was placed in operation between Nova Scotia and Prince Edward Island. This system operated in the 2000 m.c.s. band, over 47 miles of open water. It was subject to severe outages due to inverse bending, but after the installation of a mid point repeater, it provided a satisfactory service until it was replaced in 1957 with a 6000 m.c.s. system over a slightly different route, using space diversity on a 37 mile over-water hop. In 1951 another 2000 m.c.s. system was established between Halifax, N.S., and Saint John, New Brunswick. One of the paths on this system is a 50 mile over-water hop, using triple vertical space diversity. In 1955 a 4000 m.c.s. path was established between Nova Scotia and Prince Edward Island, using frequency diversity. In the same year a 4000 m.c.s. system was established from Sydney Mines, N.S., through Saint John, N.B., to the U.S.A., with a connection to Halifax. A 2000 m.c.s. system is now being installed from Sydney, N.S., following roughly the same route as the 4000 m.c.s. Sydney Mines system to the center of Nova Scotia, and thence over the route of the 2000 m.c.s. system across the Bay of Fundy to Saint John, N.B., with a spur to Halifax as it passes through Nova Scotia. Portable 6000 m.c.s. equipment is used in the area and numerous operations have been successfully conducted over 35 and 45 mile over-water paths, with and without diversity. Numerous V.H.F. facilities are also provided in Nova Scotia for communication purposes. The apparent affinity for radio in the Maritime Provinces had its beginning in 1941, when a 40 m.c.s. system was established between Digby, N.S., and Saint John, N.B., and of course, even that was on a 43 mile over-water path. That particular system has since been replaced with a 450 m.c.s. system over a slightly different over-water path. A 450 m.c.s. system also connects Prince Edward Island and New Brunswick via a 43 mile over-water path.



MICROWAVE SYSTEMS IN NOVA SCOTIA

Fig. 4.

Previous to the establishment of the Halifax-Saint John 2000 m.c.s. system in 1951, difficulty was anticipated on the 50 mile over-water path. Thus prolonged propagation tests were conducted across the Bay of Fundy. Initial tests, using space diversity, showed that although individual fades were in excess of 40db., the best signal did not fall more than 10db. below the mean for 95% of the time. For the remaining 5% of the time, fades as deep as 25db. were experienced. Based on these test results, it was anticipated that the signal to noise ratio on a derived channel using FlA weighting would not be worse than 46db. for .02% of the time. This was the limit set by the user as a considered outage. The signal to noise ratio was expected to be not worse than 58db. for 0.2% of the time. Theoretical space diversity was used, and a third antenna was located half the calculated spacing below the bottom antenna. This was warranted, since it subsequently appeared that the fog layer, sometimes prevalent over the Bay of Fundy, was not sufficiently high to affect the direct ray, but did cause severe refraction to the reflected ray, while the direct ray experienced only normal refraction. This, along with the 50 ft. tides in the Bay of Fundy, could upset the diversity spacing. This system eventually consisted of 2, two-way paths, each carrying 23 toll quality circuits with 1, two-way protection path which was switched manually at the ends, solely for equipment protection. Records over the past 9 years on this system, show that reliability and performance figures were maintained within limits, but that maintenance costs based on capital expenditure were higher than for other types of system. This system is an example of the use of microwave on a light-route basis. The distance between Halifax and Saint John via land line, is some 300 miles, whereas the radio distance with five repeaters is 135 miles. The radio system was provided for a fraction of what it would have cost to provide the same facilities on open wire, and while maintenance costs were 5.95% on an annual basis; this is still some 2% higher than other microwave systems in the same area.

In 1956, a severe ice storm inflicted extensive damage to outside plant installations in Prince Edward Island. In a matter of a few hours, $300,000 worth of plant was entirely wiped out. This led to an extensive study which resulted in the replacement of the entire main toll lead through Prince Edward Island, with a 6000 m.c.s. radio system at a cost less than that inflicted by the storm. This system includes a 37 mile over-water path, with vertical space diversity and partial blocking of the reflected ray. The reliability of this system is in excess of 99.9%, and the performance of the system is maintained within limits with maintenance costs representing 3.5% of the capital investment on an annual basis. The system will carry some 60 long distance circuits and 3 high quality program circuits. It is essentially a 120 channel system, but the extra loading introduced by the program circuits reduces the traffic capacity.

A sample calculation to determine the noise performance of a specific path will be shown. Once the C/N ratio is known at the input to the radio receiver, the channel noise performance can be established, based on characteristics of the multiplex equipment used.

N_r Receiver Noise Level
P_t Transmitter Output
G_t Transmitting Antenna Gain
G_r Receiving Antenna Gain
L_{rt} Miscellaneous Filter and Transmission Line Losses
A Path Loss

These calculations are based on a receiver with a 14 m.c.s. bandwidth to the −3db. points, and a receiver noise figure of 14 db.

1. $N_r = NP(\text{Thermal Noise}) + N_f(\text{Receiver Noise Figure})$

$$NP(\text{dbm}) = -174 + 10 \log BW \text{ (cycles I.F.)}$$

$$NP(\text{dbm}) = -174 + 10 \log 14{,}000{,}000 \text{ c.p.s.}$$
$$= -174 + 71$$
$$= -103 \text{ dbm}$$
$$N_r = -103 + 14$$
$$= -89 \text{ dbm}$$

2. P_r (Received Carrier Power) $= P_t + G_t + G_r - L_{rt} - A$

3. $C/N_{rf} = P_r - N_r$

The 6000 m.c.s. path between Fraser Mountain, Nova Scotia and Mount Buchanan, Prince Edward Island is 37 miles long. The following values have been used to determine Pr.

P_t	+20 dbm
G_t	40 db
G_r	40 db
A	140 db
L_{rt}	6 db
N_r	−89 dbm

$$P_r = 20 + 40 + 40 - 6 - 140$$
$$= -46 \text{ dbm}$$
$$C/N_{rf} = -46 + 89$$
$$= 43 \text{ db}$$

Most equipments will maintain a sufficient signal to noise ratio on a derived circuit down to a C/N_{rf} of 10 db. Thus on this basis, in the case at hand, there is a 33 db. margin on this path.

It has been an established fact for some years that microwave systems can provide excellent communication facilities. Until the past few years the emphasis has been on long haul systems. The same techniques apply for short haul facilities with the possible exception that in some cases the requirements may not be quite so severe. Each case must be investigated on its own merits and planned accordingly. Fig. 4 shows various applications of light route and heavy route microwave equipments as applied to specific communication problems in Nova Scotia and Prince Edward Island in particular and their connections with the neighboring Province of New Brunswick. In the more sparsely populated areas there is an important part to be played by light route microwave systems. If the area eventually grows to the point where heavy route equipment is required, the provision of interim light route facilities is usually justified on a cost basis.

It is the obligation of the system design engineer to provide a communication system with the best reliability and performance consistent with the economics of a given application. The field of light route microwave offers great possibilities in sparsely populated areas and in the case of a potential user whose requirements are for not more than a few hundred circuits.

References

Reference Data for Radio Engineers, 4th Edition, I.T.&T. p. 745 and p. 746.
Bell System Practices............R105.040

BATHURST'S NEW 1250 p.s.i.g. KRAFT CHEMICAL RECOVERY BOILER AND BACK PRESSURE TURBINE

(Continued from page 75)

A conventional alternator is connected to each turbine wheel making a double ended unit supported in the middle by the turbine casing. The alternators are connected electrically so that they are always synchronized as long as the field current is on.

A sectional view of this turbine is shown in Fig. 5, and Fig. 6 shows a picture of the turbine installed in the turbine room.

The turbine was purchased to operate most efficiently at 120,000 lb. of steam per hr. with inlet steam at 1225 p.s.i.g. and 850°F with exhaust pressure at 165 p.s.i.g. The turbine was designed to take 900°F steam if at a later date another boiler operating at higher temperatures might feed some steam to its header. At the above steam flow, the unit was guaranteed to deliver 5,650 kw. The maximum capacity with the overload valve open is 150,000 lb. per hr. and 6.540 kw. A change in blading can be made easily for other capacities up to a maximum efficient flow of 150,000 lb. per hr. and 7,250 kw. or an overload condition of 184,000 lb. per hr. and 8,300 kw. A new set of blading can be purchased for about $35,000 for a high load condition if another 1250 lb. boiler is installed in the future. The change is quite simple and can be made in a short down period of about a week. The generators are rated at 8,750 kw. so that they are ample for future higher turbine capacity.

The turbine normally operates with the throttle valve wide open with no governor. Speed is controlled by the generators being synchronized with the other machines and load is determined by the amount of steam made by the boiler. The overload valve has been disconnected. If the boiler flow happens to go a little above normal full load, the pressure at the turbine will go a little above normal until this additional steam is pushed through. A pressure actuated governor controls the throttle if the boiler pressure drops due to low fire or a sudden loss of fire, so as to hold the boiler at 1250 p.s.i.g.

The boiler and turbine were ordered in July 1956 and went into operation early in September 1958. Equipment throughout the plant performed as expected after a very successful start up. In general, there has not yet been any reason to regret any of the major design decisions and engineering applications involved in this project.

Discussion

OIL TANK SITES PRELOADED BY WELL POINT SYSTEM

Ronald F. Scott, M.E.I.C.
Formerly Divisional Soil Engineer,
Racey McCallum & Associates Ltd., Toronto
The Engineering Journal, August 1959, p. 79.

Author's Reply

It is very kind of Mr. Kenney to appraise my paper so generously. As Mr. Kenney surmises, my intention was merely to present a description of the method and technique of preloading the tank sites and only enough soil information was given in the paper to make the discussion clear. I am preparing a much more detailed and technical paper for publication elsewhere, to incorporate the measurements made since the writing of the paper under discussion and to include more soil information.

However, it is possible, I think, to give enough data at present to answer most of Mr. Kenney's questions, which I will deal with under the headings he has used.

1-Classification and Shear Strength

(a) The sediments at the site generally varied in color from light to dark grey, but under a part of the area the soil had a reddish brown color. In this case closer inspection showed that the varves were alternately grey and red, the red material being clay, the grey, silt or clayey silt. At this site no attempt was made as part of the investigation to obtain moisture contents, limits, or grain size analyses for the different soils in the varves. It is difficult to say how distinct the layers were, but they could easily be seen on fresh samples before any drying out took place even on the all-grey soils. The varves did not appear generally to grade into each other, but of course the soil varied greatly from depth to depth and place to place.

The thickness of individual varves also differed from sample to sample. I think I can say fairly that the varves were generally thin, of a thickness of ⅛ to ½ in., but I have a note of one sample in which the clay layers were about ¾ inch thick, separated from each other by ⅛ in. thick silt or clayey silt zones. In many of the samples from shallow depths (20-30 ft.) the thicker varves seemed to predominate while at greater depths (40-50 ft.) the varves were generally thinner. Variations in thickness occurred at all depths, however. We did not make notes on the manner in which the relative thickness (of silt to clay layers) varied with depth.

(b) The original calculations were based on the results obtained from samples from five boreholes which were supplemented by two additional holes as checks in the areas of the tanks before construction. In the clay layers, 2 in. diameter Shelby tube samples were obtained at 5 ft. intervals in the first set of holes, 3 in. diameter Shelby samples in the two supplementary holes.

In the "varved clay" of Fig. 2 of the article, the average moisture content is given as 60%; it actually varied from about 50-55% at the top of the layer to about 65-70% at the bottom, based on mixed samples. No moisture content determinations in the individual varves were made. The top and bottom boundaries of this layer varied from hole to hole and were not easy to distinguish except on the basis of water contents and sensitivities.

In the "varved silty clay" of Fig. 2, the moisture content of mixed samples did generally decrease from about 35% at the top to about 25%, but in two individual holes it remained constant, close to 30%, with depth.

The nautral moisture contents in both layers varied from the liquid limit to 3 or 4% higher than the limit. That is say, the liquid limit in the upper clay layer increased from about 50% at the top to about 60 to 65% at the bottom, while in the underlying layer ("varved silty clay") the liquid limit decreased from about 30% at the top to about 25% at the bottom of the layer. As far as can be indicated from the data, straight line variation between these boundary values can be assumed.

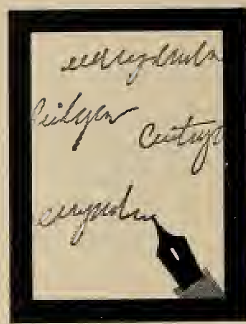
The plastic limit of the upper clay layer appeared to diminish slightly with depth, from about 30% at the top of the layer to about 25% at the bottom. The plastic limit of the lower silty clay was relatively constant with depth at a value of about 20%.

(c) The field vane shear strength increased very nearly linearly with depth through clay layers from average values of 500 p.s.f. at the (approximately) 24 ft. depth in Fig. 2 to about 1500-2000 p.s.f. at 70 to 75 ft. depth. The ratio of shear strength to calculated intergranular stress, c/p, had an average value of about 0.30 to 0.35 in the upper clay layer, but about 0.41 in the lower layer.

In the upper clay sensitivity based on the vane test varied from 2.5 to 3.5; in the lower layer from 1.5 to 2.5. No particular variation with depth was observed. Laboratory unconfined compression tests on 2 in. diameter, 4 in. high samples as usual gave a

(Continued on page 142)

Abstracts



The Greater Winnipeg Water District's Second Branch Aqueduct and Low Lift Pumping Station
N. S. Bubbis, M.E.I.C.

Organized in 1913 to bring water from Lake of the Woods into Greater Winnipeg, the Greater Winnipeg Water District is currently undergoing construction of additions and extensions. Discussion of: history; design considerations; method of guaranteeing the required flow coefficient; problems, methods, and plant used in manufacture and installation of 66 in. embedded cylinder prestressed concrete pressure pipe. Comparison of bridge, riverbed and rock tunnel crossings. Comparison of two methods, a dam at Ash Rapids in Shoal Lake vs. a low lift pumping station. Description of: selection of pumps, design, safety measures to protect aqueduct when pumping, and construction methods.

Sault Ste. Marie International Bridge
C. H. Gronquist

The crossing of the St. Mary's River to connect the two "Soos" by a vehicular bridge has long been considered essential to the growth and development of the area. The bridge, financed in large part by the International Bridge Authority, will have a 28 ft. concrete asphalt surfaced roadway. Statistics: 11,684 ft. long including plazas; maximum bridge grades of 3¾% on U.S. side and 4% on Canadian; 430 ft. Main Span continuous trusses of arch form. Substructure: two-legged concrete bents for truss spans; single shaft hammerhead type piers for beam spans.

Joints in Precast Concrete Building Frames
E. M. Rensaa, M.E.I.C.

Structural efficiency and the economy of precast reinforced concrete building frames depend largely on methods of joining. Since little saving of material results from precasting beams and columns, savings must come in the form of work and labour. A chief advantage of cast-in-place frames is continuity. Study of possibility of obtaining continuity in precast frames. Results obtained in developing suitable joints for precast concrete beams and columns. Jointing under winter conditions.

The Work of the Column Research Council
D. T. Wright, M.E.I.C.

A description of the Column Research Council with special reference to the forthcoming major work "Guide to Column Design Specifications". Focus on problems of design involving instability of metal structures and structural elements and contributions made by Council. The guide establishes new precepts—among them that design is a complicated task. Some of the limitations of the Council's work and areas not yet treated.

The Measurement of Industrial Water Pollution
T. W. Beak

A definition of pollution related to the beneficial use of waters. Methods of measuring pollution by measurement of effects of pollution rather than by direct measurement of the causitive agent. Description of the biochemical oxygen demand test. Oxygen sag curves and their relation to B.O.D. Toxicity and methods of measuring it. Biological surveys to measure pollution. Two recently developed applications of this method.

Benefit Cost Analysis of Greater Winnipeg Floodway
Carson H. Templeton, M.E.I.C.

Methods for reducing flood damage in the Winnipeg area including dams, river diversions and floodways or bypasses around Winnipeg. An outline of the projects, including the Greater Winnipeg Floodway with its 100 million yd. of excavation. Methods used in estimating damages of floods of various magnitudes and frequencies and of comparing benefits and costs. Study of final report recommending the use of a combination of three projects at an estimated $73 million. Method of making Benefit-Cost studies.

Hydrological Investigations for the South Saskatchewan River Project
E. F. Durrant, M.E.I.C.

Flood potential at the damsite and water supply for the project. Study of basic relationships between runoff and precipitation on the Eastern slopes of the Rocky Mountains, storm studies and flood routing problems for estimation of a probable maximum flood and selection of the design flood. Determination of water supply, considering existing and future projects.

An Approximate Analytical Method for the Determination of Foundation Natural Frequencies
George Ford, M.E.I.C.

The approximate procedures outlined in this paper are based on Rayleigh's Principle and may be used to find the natural frequencies for all six degrees of freedom of rigid foundations. Application of the method to vertical and horizontal vibration. Values obtained for vertical natural frequencies of foundations agree closely with those in the empirical plot of Tschebotarioff.

Uranium City Water and Sewerage System
H. P. Klassen, M.E.I.C.

A short history leading up to National Research Council work. Description of unusual factors affecting design such as temperatures, soil conditions and rocky terrain. Methods of looping the areas with pipe for recirculation. Flows and heat requirements, with consideration of domestic and fire demands. Protection for house service connections. Flows, temperatures and fuel consumptions during the first years of operation.

Automation in Thermal Power Plants
A. R. Scott

A thermal generating station serves as a valuable example of a complex industrial process to which digital computers have been applied to the functions of data logging and alarm supervision, calculation and performance, and control. Means for measuring and converting quantities into a language the computer understands. Importance of adequate sensors for measuring pressures, temperatures, flows and electrical quantities. Application of digital control to a steam plant. Provision can be made for start up and shut down of a unit and its auxiliaries as well as control under varying load conditions. Comparison of computer control with conventional boiler, turbine and generator controls.

Design and Construction of Chute-des-Passes 345 kv. Transmission Line
H. B. White
The first unit of Chute-des-Passes generating station was completed in October and the entire five units of 200,000 hp. each are scheduled for completion in early 1960. A 345 kv. transmission system of two 345 kv. single circuit bundled conductor lines transmits the output of this station 91.2 miles for interconnection at Isle Maligne with the 2,600,000 hp. of the Saguenay hydro-electric system. Studies to establish transmission line parameters. Construction of the lines with emphasis on techniques and special equipment for string and sag of bundled conductors. Testing of full-scale guyed mast tower fabricated of aluminum structural alloys near Arvida, Que. Tests carried out on the tower and its components.

The Evolution of Large Synchronous and Induction Motors in Canada
G. W. Herzog, M.E.I.C. and *K. Z. Lukaszewicz*
The evolution of large synchronous and induction motors in Canada. Early types, applications and construction are compared with modern units produced by one manufacturer. Comparison of induction and synchronous motors with emphasis on their proper application. Motor application considerations, including the effect of environmental conditions on motor construction and size. Changes in construction types, materials and processes in relation to changing applications and increased technology. Design process for an A.C. motor.

Standard Aluminum Sub Station Design
J. R. McMullan and *Howard Meyers*
Early designs of aluminum sub stations followed closely their counterparts in steel in which standard shapes were employed and all parts bolted or riveted. A structure weighing 50-75% that of the steel resulted which cost two to three times more. Welding was impractical because heat softened the tempered alloys reducing their strength. Advent of the Alrectic system, utilizing specially extruded shapes designed to minimize the heat affected zone. A large mass of metal at the weld zone reduces annealing and permits working stresses comparable to steel. With welding columns and girders can be made in a fraction of the time required for a bolted structure. Erection is made easier by light weight. Standardization developed. Simplification of design, fabrication and erection.

Long Range Planning for the Manitoba Hydro-Electric Board
L. A. Bateman, M.E.I.C.
A discussion of factors influencing the growth of Manitoba's electrical system and proposals concerning development of the hydro-electric potential. Economic factors associated with interconnection of neighboring provinces. Availability of possible short-time markets to the South. Manitoba is one of the few areas of the world to possess natural water storage in excess of six million acres under the sole jurisdiction of the local power producers. Long-range planning. Economic factors affecting development of any combined system of hydro-electric and thermal-electric generation.

Load and Frequency Control System of the Manitoba Hydro-Electric Board
K. H. Williamson, JR.E.I.C.
Interconnection of power systems, through greater flexibility and diversity, results in increased economy and reliability for the member systems. The Winnipeg Central Load Dispatch Office is equipped to control the operation of two major interconnecting lines, the 138 kv. transmission line between the systems of the Manitoba Hydro-Electric Board and those of the Northwestern Region of the Hydro-Electric Power Commission of Ontario, and the 138 kv. tie line between the Saskatchewan Power Corporation system and Manitoba's. Provision for future interconnections. Dispatcher's equipment can be operated on either flat tie line, flat frequency or tie line bias mode of operation. High speed telemetering of tie line flows and control information recorded by frequency type telemeters. Master controller interprets the signals and causes the unit governors to respond by raising and lowering the machine outputs.

Microwave Radio Application to an Electric Utility Load Dispatch System
E. M. Scott, M.E.I.C.
In 1959 the Manitoba Hydro-Electric Board began a development program to interconnect four hydro-electric generating stations on the Winnipeg with Ontario and Saskatchewan systems. Construction of a thermal electric generating station at Brandon, Manitoba, and another at Selkirk, Man. Interconnection with the City of Winnipeg Hydro-Electric System. Considerations in establishing the new systems. Location and function of the load dispatch office in Winnipeg. Instrumentation and telemetering. Choice of particular microwave radio system. Siting of the repeater station. Usage of cold standby equipment and emergency power supplies. Integration with neighbouring utilities.

Silver Falls Tunnel and Surge Tank Design Considerations
L. A. Leeyus, M.E.I.C.
Design of the relatively high head pressure tunnel and surge tank at the Silver Falls development presented some unusual problems. Design assumptions and methods. Tunnel: concrete lined conduit, 14 ft. x 6 in., extending horizontally from bottom of vertical intake shaft at Dog Lake to the powerhouse at Little Dog Lake. Surge shaft intersects near downstream end. Tunnel and shaft linings designed for internal and external pressure. Surrounding rock structure provides resistance to internal pressure. Where rock is inadequate, loop reinforcing steel and welded steel liners used. Welding in penstock and surge tank. Selection of standpipe tank. Economic, hydraulic and construction considerations.

Concrete Lining of the Tunnel at Silver Falls G.S.
J. H. Jackson, M.E.I.C. and *C. T. Bath*
Methods used in concreting operations of the tunnel at Silver Falls G.S. A 10,000 ft. tunnel built between Little Dog Lake and Big Dog Lake to by-pass a series of rapids and take advantage of about 350 ft. difference in elevation to operate a 62,000 hp. turbine generator at Little Dog Lake. Mainly unreinforced concrete lining. Total of 760 lineal feet reinforced concrete lining, in three sections, especially at the depression area with low rock cover. Low and high pressure grouting. Concreting of the intake and surge shaft.

Whitehorse Rapids Power Development
L. A. Carey
Earthfill dam and concrete spillway were built across the upper end of the Whitehorse Rapids Gorge in the Yukon, one of the river obstacles on the trail of '98 to Dawson City. All river diversions done in the gorge with timber crib cofferdam built in below-zero temperatures. Quicksand encountered in powerhouse excavation. Canal founded on mainly pervious gravels. Earthfill structures made from local materials.

The Warsak Hydro-Electric Project (A Colombo Plan Undertaking in West Pakistan)
J. H. Ings, M.E.I.C.
Project for the generation of electricity and irrigation of some 100,000 sq. miles of land. First power will be produced in 1960. Complex organization has necessitated the work of six Canadian and eight Pakistani government

bodies. Storage development in the watershed limited by the fact that 20,000 of the 26,000 sq. miles of drainage area are in Afghanistan and the remaining 6,000 sq. miles are topographically difficult. Headpond extends to Afghan border but is in a gorge. The dam will develop 20,000 acre feet of live storage. The scheme: 250 ft. high gravity dam, a 39 ft. diam. concrete-lined power tunnel, manifold, steel-lined penstocks and a surface powerhouse, spillway section with crest gates, a stilling basin to dissipate energy of large flow within gorge, four Francis turbines of 55,000 hp. and two more to be added.

Optimum Adjustment of Governors at the Hydro Generating Stations of the Manitoba Hydro-Electric Board
L. M. Hovey, M.E.I.C.

Elementary theory of speed governing. Simple differential equation of governing shows why it is necessary to provide for speed droop in order to stabilize the prime mover. Normalized or per unit system represents speed, torque, power, etc. and the inertia effects and time delays are represented by their equivalent values in seconds. In deriving the equations of an hydraulic turbine governor, certain simplifying assumptions are made to obtain differential equations of linear form comparatively easy to solve on an analog computer. Assumed that the equation closely approximates the performance at or around the point of maximum turbine efficiency. Since all generating stations on the Winnipeg are joined by a stiff tie line near the stations, in determining optimum governor settings all machines in these plants have been treated as a single equivalent machine. Methods for measuring temporary droop and dashpot time constant. Adjustment of each to selected value.

Moran Dam and the Fraser River
Russell E. Potter, M.E.I.C.

Although the Fraser River is the greatest potential hydro power source in British Columbia, it is disqualified by its valuable salmon runs. If power were developed, only part of the runs would be affected. Every river in B.C. which enters the ocean has the same problem to some degree. The people of B.C. will have to decide whether the sockeye, the only seriously affected salmon, are to be saved or the power developed.

Design and Construction of Kelsey Generating Station Dam and Dykes
R. A. Pillman, JR.E.I.C., *D. H. MacDonald*, M.E.I.C., and *H. R. Hopper*, M.E.I.C.

Economic and schedule considerations dictated the building of a rock-fill dam on bedrock for the Kelsey Generating Station. Dykes constructed on unfrozen and permanently frozen foundations. Laboratory testing of highly plastic core materials to determine properties for design. Construction of the core in freezing weather within heated enclosures placed upon the dam. Dykes built of sand on frozen ground. As foundations thaw, due to heat from reservoir, sand drains in the foundations facilitate drainage and accelerate consolidation. Design, without precedent, based upon theoretical heat transfer and consolidation considerations. Sensitive temperature and settlement measurement devices installed in foundations give warning of trouble and provide information for future structures.

Braking of Hydro-Electric Generators
H. O. Wilson, M.E.I.C.

Present practices used in the braking of hydraulic turbine driven generators. Results of tests on medium size Francis turbine driven generators. Theories and problems concerning braking encountered in generator design work. Operating philosophies on automatic braking and associated problems. Recommendation for a method of automatic braking for unattended generating stations.

Management—Horse Trading or Trusteeship?
Lyndall F. Urwick

Management has been defined in the Concise Oxford Dictionary as "trickery, deceitful contrivance". The word is derived from the French for "stable" and has, in interpretation, been associated with horse trading. However, owners and managers in a free, competitive economy must act as trustees for the interests of their consumers. Need for leadership in managers. Individualistic *laissez-faire* economy is replaced by social consciousness.

Statistical Quality Control as a Management Tool
B. H. Lloyd

Statistical quality control was initially intended to assist management in gaining a better understanding of the manufacturing process. Lag in accepting and applying statistical quality control. Importance of risk concept in applying sampling methods. Dramatic history illustrates the value of statistical method in solving problems where more conventional methods have failed. Communication between scientist and management facilitated if management is equipped to meet the scientist halfway.

An Exercise in Operations Research—RCAF Aircraft Maintenance
W/C A. B. Howell

A development of expressions for aircraft group response to change. Relating these expressions to work output equations provides means of analysis for better guidance of aircraft maintenance and flying management. Expressions for rates of becoming unserviceable and for manpower ability to recover a serviceable state. Practical Tests. Demonstration of Analysis methods. Model and analytical methods made possible by it are fitted to RCAF usage and requirements but promise application to other forms of aircraft operational management.

Recent Advances in Experimental Stress Analysis
J. B. Mantle, M.E.I.C.

Review of recent advances in experimental stress analysis techniques with examples of their application. Discussion of photoelastic stress analysis, including the new photostress technique, the photostress gauge, and some of the newer materials for three-dimensional stress analysis work, such as Hysol 6000 OP and photoelastic casting resin EPA. Electrical resistance strain gauges: the new forl gauges. Experiences with dynamic stress analysis in the microsecond range using standard gauges.

Liquid Petroleum Gases As Fuels for Automotive Engines
Henry A. Spencer, M.E.I.C.

Seasonal surpluses of butane and propane require a new market. Research directed to automotive uses, particularly in farm vehicles. Equipment available not satisfactory. Examination of commercial conversion equipment to find reasons for lean mixture tendencies. Methods of overcoming the basic problems. Utilization of butane for automotive engines in cold weather. Burning of propane with diesel in an automotive diesel engine. Control for variable speed engines and indications of greater horsepower.

The Application of High Powered Epicyclic Gearing for Marine and Industrial Uses
H. N. G. Allen, and *T. P. Jones*

Rapid progress during the last fifteen years in the application of epicyclic gearing to high speed, high torque and high powered conditions. This gearing is suitable for speed reducing and speed increasing applications. Developments for speed change, reverse reduction or de-clutchable applications. Use of combined co-axial and parallel axis gearing. Ability to deal with high speeds and torques without exceeding recognized maximum tooth speeds and stresses. Unusual form of hardening tooth components; comparison of results with the more usual carburising method. Illustration of many types of installation and application.

Design of Industrial Gears
R. D. Mutch, M.E.I.C.

Investigation for a new kind of gear began with the difficulty of relating face width to pitch in the existing gears. Attempt to establish method for calculating the face width necessary for varying loads, speeds and materials to use this value to determine the size of tooth required. Comparison of helical gears with spur gears. Description of test set, results and conclusions.

Automation and Control Engineering in Canada

Control of Steel Plate and Strip Mills

THIS article outlines the methods of producing plate and strip in the steel industry, and indicates some of the ways in which automatic control can improve and maintain the quality of the end-product. The general principles involved apply equally to operations on other metals.

Steel slabs and heavy plate are generally made from hot ingots (as cast after production in the steel furnace) in a reversible rolling mill; that is, the ingot or slab passes one way along the mill table, through the rolls which reduce the slab thickness, and along the table at the opposite side until clear of the rolls. The slab is then stopped, the roll opening reduced to a predetermined size, and the mill reversed to pass the slab back through the rolls; and so on, until the required slab thickness is reached. Actually, rolling is continued until the original size is reduced by 10% or more, and the slab is then rotated 90° and rolling completed in the new direction, for metallurgical reasons.

Considerable reduction in size can be attained on reversible mills, but relatively thin strip is often made on hot or cold strip mills, which are operated in one direction only. Whereas reversing mills are of the single-stand type (i.e., have only one set or stand of rolls), strip mills may have several stands of rolls in tandem. Hot strip mills are more difficult to control automatically than cold reduction types because of the added factor of temperature variations.

The slab or strip is passed between two motor-driven work rolls, each of which is supported by one or more back-up rolls. The gap between the rolls is adjusted mechanically by means of a screw-down motor.

Reversing Mills

When a standard thickness of plate is produced from regular ingots on a hot reversing mill, the operation can be automated by a punched-card system, for example, that can store the sequence of roll screw-down settings required. A set of instructions can be acquired for each type of plate or slab produced. A recent development in this field, the first of its type in the United States steel industry, is the use of a magnetic drum to store a whole library of rolling schedules; this should be more satisfactory than punched cards, which need more careful handling in an environment such as a steel mill.

Control by computer is a favourite topic these days, and it crops up again in connection with hot plate mills. Several installations are in existence, one example of which is a transistorized digital computer used to control a slabbing mill that is used for production of special orders, rather than long runs of standard sizes. The operator feeds in the initial roll opening, succeeding drafts to be taken after each pass, and the end limits of thickness. The computer applies the setting reference signals directly to the roll screwdown system and automatically controls all the mill passes necessary to bring a piece to required thickness limits; it calculates the intermediate roll settings needed. A load cell on the rolls senses when the metal leaves the rolls, to stop the rolls and mill table when the pass is complete, and to start the screw-down to the next setting. An infra-red scanning device gauges the length of the metal as it leaves one end of the mill.

Automatic Gauging Control

Steel strip is produced in many gauges within certain limits of thickness; these tolerances become ever closer as demand for improved quality increases. Several methods are in use for automatic control of gauge during rolling operations.

In practice, the actual reduction in thickness of a strip during rolling can be achieved in more than one way. When squeezed between rolls the strip flows plastically to a certain resultant thickness; however, if tension is applied to the strip at either the entry to or exit from the rolls, the roll pressure decreases and the rolls tend to move closer together, so producing a thinner strip under the new equilibrium conditions of the work system. The net result is that the strip can be reduced by the increasing roll pressure alone (usually the case in making plate or heavier gauges of strip), by increasing tensions, or by a combination of the two. In practice there is a limit beyond which increasing roll pressure alone may not continue to decrease emergent thickness of strip, because of flattening effects on the rolls.

There are three methods of measuring thickness of metal in a rolling mill: contact gauges, non-contact gauges, and the mill stand itself. Contact gauges use small rolls in contact with the strip; the separation of these rolls is measured mechanically and converted to an electrical indication of thickness. The non-contact gauges are the familiar x-ray or gamma-ray absorption type used in several industries. Both these types have the disadvantage that the sensing device must be some distance from the work rolls, thus introducing an element of delay in controlling thickness variations.

The third method of measuring thickness gives instantaneous reading of changes in dimension. It uses the principle that the mill stand and rolls act as a large spring; from the relation between roll-separation before and after metal enters the rolls, a measure of thickness can be obtained. The roll separating force is measured by load cells mounted behind the back-up roll chocks; when this force is divided by the spring constant of the mill and the result added to the unstressed roll separation, a value of the stressed roll separation (and hence the strip thickness) is obtained. The calculation is done electrically and the resultant instantaneous indication of thickness can be used in closed-loop gauge control with an advantage over other methods of thickness measurement that involve transport delay.

Certain inaccuracies must be guarded in this method of thickness measurement, which does not take into account changes in roll diameter. Where diameter changes slowly (e.g., due to thermal expansion of wear), compensation can be made manually or automatically by recalibration from, say, an x-ray or gamma-ray gauge which feeds back a true thickness signal that can be compared with the signal from the mill stand meter. Rapid variations in diameter may result from eccentricity of back-up rolls; this may be small enough, compared with accuracy required on the finished product, to be ignored, but precautions may be necessary, particularly on cold mills, to counter eccentricity. If sufficiently serious, the mill stand gauge may become less accurate than the non-contact type of gauge for control purposes.

Single Stand Mills

A single stand reversing cold mill may use screw pressure to control thickness of heavy gauges, back tension to control thickness in lighter gauges, or a combination of methods. Several automatic gauge controls have been applied to this type of mill; for example, systems using radiation thickness gauges on either side of the rolls with control being effected by screw-down. Because there is a time lag between mill roll bite and the gauge, such controls are of the sampling type.

One Canadian installation uses the mill stand meter principle, as described above, to indicate deviation of strip thickness. The particular installation can vary both screw setting and back tension. Rolling speeds are usually fairly slow, and operators have achieved good control down to thread speed. The advantage of the mill stand method here over the radiation gauge is particularly marked because of the slow speeds which tend to lengthen the transport time lag in the latter case. In this installation radiation gauges are used on either side of the rolls to keep the mill stand meter in calibration, as discussed above.

Tandem Multi-stand Mills

There are many more variables that could be controlled to limit thickness of strip from a multi-stand tandem mill. Considering a cold-rolling operation, to avoid further complication, it is possible to vary thickness at each stand by altering roll pressure or tension at entry or exit. Thus, in a five-stand mill, five screwdowns and six tensions could be varied. In theory, all of these could be controlled, but in practice it is possible to attain desired manufacturing limits with control of only one or two variables.

One development from manual control practice with this type of mill has been the regulation of fairly constant thickness from the first stand by monitoring an x-ray gauge after the stand and thence regulating the screw-down on the stand, on a sampling basis. 'Fine' control is then obtained by a regulator that continuously monitors a gauge after the final stand and controls the speed of the motor on the last stand. In many cases it is possible to control thickness within commercial limits by using the first-stand or 'coarse' control alone.

Hot Strip Mill Control

The control of thickness on multi-stand hot strip mills is much more complex than on a cold mill. The temperature of the incoming material may vary because of water cooled skids in the reheat furnace and general cooling on the approach tables. The result of varying temperatures in preceding mills may be a variation in thickness of the incoming material. In addition, the gauge of the first and last hundred feet or so of a strip may be heavy because these ends have to be rolled without the assistance of tension.

It is found in practice that the tension between stands of a hot strip mill must be kept fairly constant, within quite close limits. Too-low tension causes poor tracking; too-high tension tends to neck down the strip width and significantly increase tail end thickness. Hence, most gauge control on this type of mill should be by screw-down, with some slight tolerance of tension variation.

One system used on a six-stand hot mill has mill stand meters on stands 2, 3, 4, and 5 to control screw-down, as described above for the case of a single-stand mill. Such a system avoids much change in inter-stand tensions and so does not affect strip width. A radiation gauge after the last stand is used to monitor the system and record final strip thickness.

Some progress is being made to satisfactory operation from less complicated, and therefore less expensive, control systems. Thus, the number of meter/screw-down controls has been reduced to two (on stands 2 and 3), with a meter/tension control on stand 5. Finally, the system may be reduced to screw-down control on stand 2 only plus tension control on stand 5. Where close control of tension is needed, it is found necessary to provide speed regulators in the system.

In fact, speed regulators at each stand would maintain pre-set speeds and eliminate variations due to impact loading or other conditions that could have an adverse effect on metal gauge.

Towards Full Integration

Some particular aspects of control of steel rolling operations have been discussed. The industry is working towards complete integration of such operations (not to mention fully-integrated blast-furnace and open-hearth operations).

Perhaps one of the main difficulties is the lack of practical experience, but this is being overcome by observations on the existing types of control installation and the analysis of the problems involved on digital and analog computers.

When these problems have been worked out and the production of the necessary equipment is economically feasible, then it will be possible to describe the fully-integrated steel mill.

Canadian Developments

If the predictions made recently by the British Columbia Power Corporation's president, A. E. Graur, concerning Canadian economic prospects for the coming year are an indication of the general prospects for 1960, the year will be a more productive one than 1959. Business and government capital investment should reach a peak totalling $8.8 billion, a 4% increase. The Corporation's purchase of the coal deposits at Hat Creek, B.C., which may have a power generating capacity equal to the full development of the Peace River or the Upper Columbia, is thus a sign of the times.

C.C.A. Makes Submission to the Federal Government

Following their 42nd Annual General Meeting in Calgary, the Canadian Construction Association submitted a brief to the Federal Government concerning C.C.A. policies which pertain to Federal Government activities. The introduction of this submission points out that the construction industry is Canada's largest, its annual value $7.3 billion and its on-the-site employment over 600,000. The following recommendations have been made by the C.A.A.:

National Highway Policy: (1) Establishment of a National Highway Policy and Organization to coordinate on a continuing basis the long-term planning, financing and construction of roads of national importance (1952). (2) Federal investment in roads under provincial jurisdiction on an equitable basis for the improvement of Canada's main highway system and in accordance with regional needs for access roads, international connections and grade separations (1947, 1953).

Housing: (1) Allocation of funds to Central Mortgage and Housing Corporation for National Housing Act investment activities. (2) Amendment of the N.H.A. provisions for rental projects so as to be more attractive to investors (1958).

Wintertime Construction: (1) Continuation of the Federal Government's efforts designed to increase the volume of wintertime construction and employment (1956). (2) Increased research activity by NRC in the field of wintertime construction (1960).

Canadian Nuclear Association in Planning Stages

The first step toward the formation of a Canadian Nuclear Association was taken at the recent First Canadian Conference on Uranium and Atomic Energy in Toronto. Chairman of the ad hoc steering committee is J. L. Olsen, Jr. E.I.C., of Peterborough, and the following will be represented on it: A.M.F. Atomics (Canada) Ltd., Canadian Bechtel Ltd., Canadian General Electric Co., Canadian Westinghouse Co., Foundation Co. of Canada, Orenda Engines Ltd., Rio Tinto Mining Co. of Canada, and the University of Toronto.

B.C. Harbours Projects

The National Harbours Board plans to spend $1,257,000 during 1960 on capital expenditures in the Port of Vancouver, according to plans tabled in Ottawa. In comparison, $16,868,450 is to be spent on the port of Montreal. The money for Vancouver works will go mainly toward completing the new Centennial Pier, where storage sheds need to be built and movable cranes installed.

Winnipeg To Have New Air Terminal Building

A $10 million air terminal building for the Winnipeg International Airport has been announced by Transport Minister George Hees. The Winnipeg International Airport is the main central terminal airport in the Canadian system and, because of its central location, is the major distributing centre for the Prairies, Western Ontario and Northern Canada.

The new terminal building should be completed in 1964 and will consist of two units, an administration building for the operational services of the Department of Transport and the terminal building proper to accommodate airlines and public.

New Brunswick Base Metals Mining

J. Roger Pichette, Minister of Industry and Development, recently announced a new financial and sales manoeuvre between the Brunswick Mining & Smelting Company and Sogemine's Ltd. which may mark the beginning of a substantial development in the base metal producing area near Bathurst, N.B. Predictions have been made that in three years' time a smelter could be put into operation in Bathurst and subsequently plants might be built to produce sulphuric acid, iron, fertilizers, and all the various by-products of a fully-integrated mining operation like Trail, B.C.

Gas and Oil in Northern Territories

The sale of oil and gas exploration permits has reached $10 million in the past two years and another million acres has been opened up to search. All but one of the 17 parcels of land most recently bid on were in the Fort Simpson area of the Northwest Territories about 150 miles north of the B.C. boundary. To maintain their permits over the next nine years (three three-year terms) companies are required to spend a combined total of $2½ million.

South Saskatchewan River Project

The winter work program on the South Saskatchewan River Project has kept development on schedule. From October to March the program involved heaping granular material on the downstream section of the dam and raising the perimeter dyke around the river section of the west embankment. Four hundred people were employed at moving these materials which have to be compacted, an operation unique in Western Canada.

Through the same period work on the superstructure of the construction bridge continued, with the supply of 1,700 tons of structural steel to the damsite, 1,500 tons of which has now been erected. Some 55 tons of reinforcing steel was also placed during this period and the bridge superstructure, four 200 foot spans and approach girders, is now nearly completed.

Use of Test Buildings in Building Research

G. O. Handegord, M.E.I.C., *N. B. Hutcheon,* M.E.I.C.

Recognizing that test buildings are not always a valid approach to research into building problems, the authors outline the kinds of building research studies for which test buildings are useful. Description of test buildings in use at NRC's Division of Building Research. Their potential contribution to the solution of particular problems.

The Formation of Continuous Chips in Metal Cutting

W. B. Rice, M.E.I.C.

An experimental investigation of the formation of continuous chips in metal cutting. Description of a mechanism different from those assumed in classical analyses observed during orthogonal cutting. Mechanism used to explain chip-curl and cratering wear. Observation by high speed photography of the formation of continuous chips.

(More Abstracts Page 196)

How To Obtain Preprints

Preprints of the following Annual General Meeting Technical Papers may be obtained by forwarding a suitable remittance to:

The Librarian, 2050 Mansfield St., Montreal, Que.

The nominal charge of $0.50 per paper for members and $1.00 per paper for non-members has been fixed to cover handling expenses.

Liquid Petroleum Gases as Fuels for Automotive Engines.
H. A. Spencer, M.E.I.C.

Construction of the Warsak Hydro-Electric and Irrigation Project.
C. G. Kingsmill, M.E.I.C.

Economic Aspects of Industrial Power Plants.
H. R. Wright, M.E.I.C.

The Structural Behaviour of Highway Bridge Decks.
S. D. Lash, M.E.I.C., B. B. Hope.

Long Range Planning for the Manitoba Hydro-Electric Board.
L. A. Bateman, M.E.I.C.

The Evolution of Large Synchronous and Induction Motors in Canada.
G. W. Herzog, M.E.I.C., K. Z. Lukaszewicz.

Design and Construction of Chute-des-Passes 345 KV Transmission Line.
H. B. White, M.E.I.C.

Automation in Thermal Power Plants.
A. R. Scott.

The Principles of Automatic Control.
A. Porter, M.E.I.C.

Optimum Adjustment of Governors at the Hydro Generating Station of the Manitoba Hydro-Electric Board.
L. M. Hovey, M.E.I.C.

The Warsak Hydro-Electric Project.
J. H. Ings, M.E.I.C.

The Application of High Powered Epicyclic Gears for Marine and Industrial Use.
H. N. G. Allen, T. P. Jones.

White Horse Rapids Power Development.
L. A. Carey.

Engineering Computation in the Chemical Industry using Digital and Analog Computers.
V. J. Bakanowski, M.E.I.C., R. N. Boyd, M.E.I.C.

Standard Aluminum Sub-station Design.
J. R. McMullan, Howard Meyers.

An Approximate Analytical Method for the Determination of Foundation Natural Frequencies.
George Ford, M.E.I.C., J. B. Haddow.

Uranium City Water and Sewage System.
H. P. Klassen, M.E.I.C.

Moran Dam and the Fraser River.
R. E. Potter, M.E.I.C.

Management — Horsetrading or Trusteeship?
Lyndall F. Urwick.

Statistical Quality Control as a Management Tool.
B. H. Lloyd.

Soil Problems Encountered in Mining on the Canadian Shield.
R. F. Legget, M.E.I.C., W. J. Eden, r.E.I.C.

Concrete Lining of the Tunnel at Silver Falls Generating Station.
J. H. Jackson, M.E.I.C., C. T. Bath.

Preprints of the following papers have been delayed but it is expected that they will be available at Winnipeg, where copies may be obtained at the Library Exhibit.

Design and Construction of Kelsey Generating Station Dam and Dykes.
R. A. Pillman, Jr.E.I.C., D. H. MacDonald, M.E.I.C., H. R. Hopper, Jr.E.I.C.

Design of Industrial Gears.
R. D. Mutch.

The Dunvegan Suspension Bridge.
T. Lamb, M.E.I.C., R. N. McManus, M.E.I.C.

Design and Erection of Structural Steel for The International Nickel Company's Thompson Project.
W. H. Bender.

Sault Ste. Marie International Bridge.
C. H. Gronquist.

The Greater Winnipeg Water District's Second Branch Aqueduct and Low Lift Pumping Station.
N. S. Bubbis, M.E.I.C., R. C. Sommerville, Jr.E.I.C.

A New Canadian Structural Test Installation.
W. R. Schriever, W. G. Plewes, Jr.E.I.C.

The Measurement of Industrial Water Pollution.
T. W. Beak.

Benefit Cost Analysis of Greater Winnipeg Floodway.
C. H. Templeton, M.E.I.C.

Manned Space Flight.
Orest Cochkinoff.

Hydrological Investigations for the South Saskatchewan River Project.
E. F. Durrant, M.E.I.C.

The Work of the Column Research Council.
D. T. Wright, M.E.I.C.

The Economics of an Industrial Gas Turbine Installation.
D. Panar, M.E.I.C.

Development of Western and Northern Canada's Mineral Resources.
John Convey.

Silver Falls Tunnel and Surge Tank Design Considerations.
L. A. Leeyus, M.E.I.C.

The Khulna Newsprint Project.
D. P. Wyness.

Microwave Radio Application to an Electric Utility Load Dispatch System.
E. M. Scott, M.E.I.C.

Braking of Hydro-Electric Generators.
H. O. Wilson, M.E.I.C.

Future of Western Canadian Potash.
W. J. Pearson.

Recent Advances in Experimental Stress Analysis.
J. B. Mantle, M.E.I.C.

Load and Frequency Control System of the Manitoba Hydro-Electric Board.
K. H. Williamson, Jr.E.I.C.

Joints in Precast Concrete Building Frames.
E. M. Rensaa, M.E.I.C.

The Formation of Continuous Chips in Metal Cutting.
W. B. Rice, M.E.I.C.

The Use of Test Buildings in Building Research.
N. B. Hutcheon, M.E.I.C., G. O. Handegord, M.E.I.C.

The Potential in the Free-Piston Engine Principle.
Anton Braun.

An Exercise in Operations Research — RCAF Aircraft Maintenance.
A. B. Howell.

The following papers were preprinted in the April issue of The Engineering Journal. Members wishing to refer to these papers at the Annual General Meeting should bring this issue with them.

Supervisory and Automatic Control for Winnipeg Unattended Pumping Station.
J. W. MacLaren, M.E.I.C., D. J. Moon, M.E.I.C., W. D. Hurst, M.E.I.C., F. G. Denson, M.E.I.C.

Silver Falls Project.
R. A. Forrester, M.E.I.C.

A High-Pressure Steam Plant for a Modern Paper Factory.
F. W. Buckley, M.E.I.C.

Application of Microwave Radio Links.
R. W. Wilson, M.E.I.C.

Salient Mechanical Design Aspects of Selkirk Generating Station.
C. W. Hodgson, M.E.I.C., A. C. Blue, M.E.I.C.

International News

Negotiations between India and Pakistan toward an Indus Waters settlement appear to have been given a considerable boost recently and a Water Treaty will likely be forthcoming in the next few months. Six countries have promised funds, through the World Bank, for the billion-dollar development which would include irrigation, hydro-electric projects, soil reclamation, drainage and flood protection for India and Pakistan.

The Indus Waters Treaty would be based on a division of the Indus Waters proposed by the Bank to the two governments in 1954. It calls for allocation of the three Eastern Rivers of the Indus system to India's use, and of the three Western Rivers to Pakistan. The division would necessitate construction of works to transfer supplies from the Western Rivers to meet irrigation needs in those areas of Pakistan which have hitherto been supplied by the Eastern Rivers. India would, of course, contribute to the cost of these works.

Canada has pledged $22.1 million over the next ten years toward development of the Indus Waters, as part of her increased Colombo Plan contribution. All pledges are subject to ratification of a water treaty between India and Pakistan. Also participating in the development plan are: Australia, Germany, New Zealand, the U.S., and U.K.

French Special Freight Cars

The Compagnie Industrielle de Materiel de Transport (C.I.M.T.) and Ateliers de Forest have designed and built two new freight cars, one with sliding roof and the other with sliding sides. They provide free access to all parts of the car and greatly speed up loading and unloading. The sliding-sides freight car is particularly designed for merchandise stocked on platforms, while the sliding-roof model facilitates loading heavy pieces by crane.

New Swedish Power Line Tower

The Swedish State Power Commission anticipates saving approximately $3,800,000, or 30% of costs, in the installation of 620-mile long 380 kv. transmission lines between Messaure and Hjalta and Kilforsen and Orevo. They are using a new lighter type of tower, the product of four years' development. Fifty pairs of such towers have been erected between the recently inaugurated Stornorrfors power plant and the Harrsele distribution centre, and light weight has been found to decrease mounting time and simplify transportation considerations.

Japanese Expressway

Japan has been granted a loan by the World Bank for construction of a 45-mile expressway between Amagasaki and Ritto, linking the Osaka metropolitan area with that of Kyoto. This is one of the more heavily industrialized areas of Japan. The development of transport facilities has seriously lagged behind other sectors of the Japanese economy, and only 10% of the 93,000 mile road network is paved. Japan now intends to invest about $2.8 billion during the period 1958-63 in a program to improve and reconstruct existing roads and build expressways.

International Atomic Energy

The Spanish government has offered 140 tons of uranium for sale to the International Atomic Energy Agency and its member states in 1960-62. The countries which have already agreed to make nuclear materials available for sale to members through the Agency are Belgium, Canada, Czechoslovakia, Portugal, and South Africa. The U.S., U.S.S.R. and U.K. have agreed to make enriched uranium available to the Agency.

A symposium on The Chemical Effects of Nuclear Transformations is to be held in Prague, Czechoslovakia, October 24-27, 1960. The director general of the Agency has invited member governments and interested international organizations to nominate participants.

English Channel Crossing

The Channel Tunnel Company is due to report this Spring on its plan for constructing an access route between England and the European continent. They have contemplated a railway tunnel with passenger trains and rail flat cars which could take 400 cars an hour. It would cost approximately $450 million. A road tunnel of 36 miles, 22 of them under sea, would over-strain drivers and be difficult to ventilate, but a four-lane steel and concrete bridge is under consideration. Such a bridge would cost about $240 million. It would be ten times as long as the record two-mile-long Zambesi River bridge in Central Africa.

Iron Ore Deposits in the Islamic Republic of Mauritania

Sixty-six million dollars have been loaned to the Islamic Republic of Mauritania in Northwest Africa by the World Bank for the development of high-grade iron ore deposits. The loan will be devoted to purchase of equipment and services to mine ore, construction of a 415-mile railway to transport the ore to port, and development of port and other facilities.

Swedish Arresting Net for Jet Aircraft

An arrester net designed to stop jet aircraft which have overrun the paved runway has been designed by the Swedish Air Board and is being adopted by the R.A.F. in Britain and NATO bases throughout Europe. A wide-mesh net catches the aircraft's wings. The four main components of the gear are the arresting net, arrangement for supporting, raising and lowering the net, lamella friction brakes with winding drums and braking wires, and anchorages.

PROVINCE OF MANITOBA
OFFICE OF THE PREMIER
WINNIPEG

April 5th, 1960.

Mr. J. H. Hanna, M.E.I.C.,
President,
Engineering Institute of Canada,
2050 Mansfield Street,
Montreal 2, Quebec.

Dear Mr. Hanna:

We in Manitoba consider it an honor to be the host Province for the 74th Annual Meeting of the Engineering Institute of Canada, from May 24th to May 27th.

With the heavy undertakings now proceeding in Manitoba, we have a special affection for the professional engineers in the Province and for those who consult with them, and so we are pleased to extend a warm welcome to them and to their colleagues.

Few people, I think, stop to realize the major role that engineers have played in the physical development of our nation, the Seaway notwithstanding. Every road, rail line, mine, factory, public service installation, utility and major building -- indeed almost every visual evidence of our progress -- bear the stamp of the man with the slide-rule.

It is, then, with considerable pleasure that we look forward to having members of the Engineering Institute of Canada and their wives amongst us.

I wish you a successful Convention and one of many enjoyable stays in our Province.

Yours sincerely,

Premier of Manitoba

STEPHEN JUBA
MAYOR

Winnipeg, 2, Man.,

April 6th, 1960.

The Members and their Ladies,
The Engineering Institute of Canada,
c/o Mr. J. H. Hanna, M. E. I. C.
President,
Engineering Institute of Canada,
2050 Mansfield St.,
Montreal, 2, Que.

Dear Ladies and Gentlemen:-

Winnipeg welcomes you! The Council and citizens of the City are delighted by the fact that the Engineering Institute of Canada will hold its seventy-fourth Annual Meeting in Winnipeg, May 25th, 26th and 27th, 1960.

Your Winnipeg Branch Annual Meeting Committee has worked hard and long in planning a program which should be of the greatest interest to all who attend the meeting, or read the papers to be presented in the Engineering Journal.

You will have opportunities to see how the City has grown and is growing, and how the work of the engineer is being used for the benefit of all.

I have been invited to be with you at your meeting and at that time I shall take the opportunity to repeat the welcome this letter contains.

The City of Winnipeg will be proud to be your hosts and we shall all do our best to make you sense our pride in having you with us.

Yours very truly,

MAYOR.

Month to Month

The Engineers Confederation Commission

The Co-ordinating Committee of the Engineers' Confederation Commission held its first meeting in Toronto on March 6, 1960 with Mr. J. H. Fox, Chairman of the Commission, in the Chair.

All committees of the Commission were represented by their respective Chairman and/or Vice-Chairman and submitted reports of their activities to date.

The main purpose of this meeting was to give an opportunity to committee Chairmen to discuss the work of their own committee with representatives of other committees and to ascertain that all committees are reasonably in agreement on major issues.

It is reported that the progress made since the first meeting of the Commission in October 1959 is very substantial and that the work assigned to the various committees is being carried out on schedule. There remains however a considerable amount of detail work to be done before any part of the final plan can be published.

The following were present at the meeting: Mr. J. H. Fox, Chairman; Mr. G. M. Dick, Vice-Chairman; Messrs. J. G. Dale, Chairman of the committee on Charter; E. D. Gray-Donald, Chairman of the committee of Finance; H. Gaudefroy, Chairman of the committee on By-Laws; W. K. Gwyer, Chairman of the committee on Branches; H. Smith, Chairman of the committee on other Societies; J. B. Mantle, Chairman of the committee on Services; T. Foulkes, Chairman of the committee on Administration; F. Bennett, Vice-Chairman of the committee on Relationship with Provincial Associations; N. S. Bubbis, Vice-Chairman of the committee on Branches; C. T. Carson, member of the committees on By-Laws and Finance; D. D. Whitson, member of the committee on Administration; L. M. Nadeau and G. T. Page, Joint Secretaries.

Cooperation with Commonwealth Engineering Societies

During the past several years the Institute has been increasingly aware of the relatively large number of members of sister Commonwealth engineering institutions who have come to live and work in Canada. Motivated by the desire to provide a "technical home" in Canada for these engineers, and to assist them in every way within the philosophy of close co-operation already existing between the Institute and its sister societies throughout the Commonwealth, in 1959 the Council appointed a special committee to investigate and recommend a suitable course of action by which the E.I.C. might best fulfil the above general objectives.

At its meeting in Montreal on February 20, the Council received a detailed and constructive report from its committee and the useful suggestions contained therein are now being considered jointly by appropriate officials of the sister societies, and the Institute has a basis for negotiating the best possible methods for providing acceptable services to members of Commonwealth engineering societies resident in Canada.

Council Appoints Committee to Study Civic Affairs and Public Relations

At the February 20, 1960 meeting, Council adopted the report of the E.I.C. Civic Affairs and Public Relations Committee regarding possible branch activity in these fields. The report reads as follows:

Recommendations:

a) It is suggested that each branch of the Institute designate one or more members of their executive committee to keep in touch with civic affairs and public relations on a local basis. In certain branches only one member of the executive may be needed. Larger branches, particularly those serving a number of communities, more than one representative may be required.

b) Such branch executive representatives should closely co-operate with any similar committee of the provincial associations or corporation.

c) No public action of any kind should be taken by these representatives until approval is given by the branch executive.

d) To indicate the field that could be covered by Civic Affairs and Public Relations representatives of the branches the following limitations are set out.

What Cannot Be Done

1) Express opinions on a national level.

2) Offer services direct to a government body.

3) Express an opinion except through the engineer on the job.

4) Publicly defend an engineer or engineering firm.

5) Make a general practice of providing free service to engineers or others.

6) Take any action that will endanger public sympathy for engineers.

What Can Be Done

1) Advise municipal and other public authorities to use the services of engineers, preferably Canadian.

2) Educate the public to leave engineering decisions to engineers.

3) Ask for more engineers at various levels of government.

4) Encourage engineers to run for public office or to serve on committees and help them get elected where possible.

5) Give support to urban transit and commuter service in the larger centers as being the most economical way of overcoming or preventing traffic congestion.

(Continued on page 134)

74th ANNUAL GENERAL AND PROFESSIONAL MEETING of

THE ENGINEERING INSTITUTE OF CANADA

May 25, 26, 27, 1960 Royal Alexandra Hotel, Winnipeg, Manitoba

Registration

Advance registration through E.I.C. Headquarters closes May 18.
Registration opens 12 noon May 24 and continues at 9 a.m. May 25 and May 26.

Accommodation

The Royal Alexandra Hotel is headquarters, with more than 200 rooms reserved for E.I.C. members and guests. Accommodation has also been set aside at other hotels and motels in the area.

Technical Program

The technical program is listed on the following 2 pages.

Ladies Program

Early plans for this include the following:

3 p.m. Wednesday, Reception at Government House.
12.30 p.m. Thursday, Luncheon and Fashion Show at the "Town and Country".
10 a.m. Friday, Engineers' wives meeting.

Winnipeg Diary

Events for all 4 days at the Royal Alexandra Hotel are listed on the back of this program.

Committee

Chairman
Mr. J. R. Rettie

Vice Chairmen
Mr. C. V. Antenbring
Mr. W. A. Devereaux

Representative & Chairman Branch Management Committee
Mr. W. L. Wardrop

Secretary
Mr. G. C. March

Publicity
Mr. N. S. Bubbis

Budget and Finance
Mr. D. C. Bryden

Technical Papers
Mr. R. E. Chant

Hotel Arrangements
Mr. F. G. Denson

Registration
Mr. W. A. Devereaux

Reception and Information
Mr. C. L. Fisher

Ladies
Mr. G. Flavell

Plant Visits & Transportation
Mr. J. MacDonald

Communications & Projection
Mr. G. A. Muir

Muriel's Room & Entertainment
Mr. R. Noonan

Annual Dinner and Dance
Mr. T. Weber

Ladies Program:
Convener Mrs. C. V. Antenbring, Co-Convener Mrs. D. Stratton

TECHNICAL PROGRAM

Wednesday, Thursday, Frid

Wednesday, May 25

Design and Construction of Kelsey Generating Station Dam and Dykes.
R. A. Pillman, JR.E.I.C., D. H. MacDonald, M.E.I.C., H. R. Hopper, JR.E.I.C.

Design of Industrial Gears.
R. D. Mutch.

The Dunvegan Suspension Bridge.
T. Lamb, M.E.I.C., R. N. McManus, M.E.I.C.

Supervisory and Automatic Control for Winnipeg Unattended Pumping Station.
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The Warsak Hydro-Electric Project.
J. H. Ings, M.E.I.C.

The Application of High Powered Epicyclic Gears for Marine and Industrial Use.
H. N. G. Allen, T. P. Jones.

Design and Erection of Structural Steel for The International Nickel Company's Thompson Project.
W. H. Bender.

EIC *Annual Meeting, 1960*

Automation in Thermal Power Plants.
A. R. Scott.

Construction of the Warsak Hydro-Electric and Irrigation Project.
C. G. Kingsmill, M.E.I.C.

Sault Ste. Marie International Bridge.
C. H. Gronquist.

The Principles of Automatic Control.
A. Porter, M.E.I.C.

Thursday, May 26

Engineering Computation in the Chemical Industry Using Digital and Analog Computers.
V. J. Bakanowski, M.E.I.C., R. N. Boyd, M.E.I.C.

The Greater Winnipeg Water District's Second Branch Aqueduct and Low Lift Pumping Station.
N. S. Bubbis, M.E.I.C., R. C. Sommerville, JR.E.I.C.

A New Canadian Structural Test Installation.
W. R. Schriever, W. G. Plewes, JR.E.I.C.

Design and Construction of Chute-des-Passes 345 KV Transmission Line.
H. B. White, M.E.I.C.

The Measurement of Industrial Water Pollution.
T. W. Beak.

Benefit Cost Analysis of Greater Winnipeg Floodway.
C. H. Templeton, M.E.I.C.

The Structural Behaviour of Highway Bridge Decks.
S. D. Lash, M.E.I.C., B. B. Hope.

Long Range Planning for the Manitoba Hydro-Electric Board.
L. A. Bateman, M.E.I.C.

Manned Space Flight.
Orest Cochkinoff.

Hydrological Investigations for the South Saskatchewan River Project.
E. F. Durrant, M.E.I.C.

The Work of the Column Research Council.
D. T. Wright, M.E.I.C.

Optimum Adjustment of Governors at the Hydro Generating Station of the Manitoba Hydro-Electric Board.
L. M. Hovey, M.E.I.C.

Panel Discussion. The Yard or the Metre—Which?
Moderator: A. H. Young, M.E.I.C.
Panel: L. E. Howlett, G. L. D'Ombrain, J. M. Thomson, D. S. Young.

The Economics of an Industrial Gas Turbine Installation.
D. Panar, M.E.I.C.

Silver Falls Project.
R. A. Forrester, M.E.I.C.

Statistical Quality Control as a Management Tool.
B. H. Lloyd.

Economic Aspects of Industrial Power Plants.
H. R. Wright, M.E.I.C.

Whitehorse Rapids Power Development.
L. A. Carey.

An Exercise in Operations Research — RCAF Aircraft Maintenance.
A. B. Howell.

A High-Pressure Steam Plant for a Modern Paper Factory.
F. W. Buckley, M.E.I.C.

Moran Dam and the Fraser River.
R. E. Potter, M.E.I.C.

Management — Horse Trading or Trusteeship?
Lyndall F. Urwick.

Friday, May 27

Liquid Petroleum Gases as Fuels for Automotive Engines.
H. A. Spencer, M.E.I.C.

Application of Microwave Radio Links.
R. W. Wilson, M.E.I.C.

Development of Western and Northern Canada's Mineral Resources.
John Convey.

Silver Falls Tunnel and Surge Tank Design Considerations.
L. A. Leeyus, M.E.I.C.

The Khulna Newsprint Project.
D. P. Wyness.

Microwave Radio Application to an Electric Utility Load Dispatch System.
E. M. Scott, M.E.I.C.

Soil Problems Encountered in Mining on the Canadian Shield.
R. F. Legget, M.E.I.C.

Concrete Lining of the Tunnel at Silver Falls Generating Station.
J. H. Jackson, M.E.I.C., C. T. Bath.

Salient Mechanical Design Aspects of Selkirk Generating Station.
C. W. Hodgson, M.E.I.C., A. C. Blue, M.E.I.C.

Braking of Hydro-Electric Generators.
H. O. Wilson, M.E.I.C.

Future of Western Canadian Potash.
W. J. Pearson.

Uranium City Water and Sewage System.
H. P. Klassen, M.E.I.C.

An Approximate Analytical Method for the Determination of Foundation Natural Frequencies.
George Ford, M.E.I.C., J. B. Haddow.

Recent Advances in Experimental Stress Analysis.
J. B. Mantle, M.E.I.C.

Load and Frequency Control System of the Manitoba Hydro-Electric Board.
K. H. Williamson, JR.E.I.C.

Joints in Precast Concrete Building Frames.
E. M. Rensaa, M.E.I.C.

The Formation of Continuous Chips in Metal Cutting.
W. B. Rice, M.E.I.C.

EIC Winnipeg, May 25, 26, 27

The Evolution of Large Synchronous and Induction Motors in Canada.
G. W. Herzog, M.E.I.C., K. Z. Lukaszewicz.

The Use of Test Buildings in Building Research.
N. B. Hutcheon, M.E.I.C., G. O. Handegord, M.E.I.C

The Potential in the Free-Piston Engine Principle.
Anton Braun.

The Standard Aluminum Sub-Station Design.
J. R. McMullan, Howard Meyers.

ANNUAL MEETING

Tuesday, May 24

9.30 a.m.	E.I.C. Committee on Education. Branch Officers' Conference.
10.00 a.m	Council Meeting.
12.30 p.m.	Joint luncheon, all conferences.
2.00 p.m.	Committee on Technical Operations. Continuation of meetings.
4.30 p.m.	Press conference.
8.30 p.m.	Reception — Muriel's Room.

Wednesday, May 25

7.45 a.m.	Authors' breakfast.
10.00 a.m.	Annual General Meeting.
12.00 noon	Muriel's Room.
12.30 p.m.	Opening Luncheon.
2.00 p.m.	Students' Conference.
6.30 p.m.	Muriel's Room.
7.00 p.m.	Dinner.
9.00 p.m.	Social evening.

Thursday, May 26

7.45 a.m.	Authors' breakfast.
9.00 a.m.	Professional Development Committee. Consulting Engineers — Directors' meeting.
10.00 a.m.	New Council Meeting.
12.00 noon	Muriel's Room.
12.30 p.m.	Honours and awards luncheon.
2.30 p.m.	Consulting Engineers' Annual Meeting. Professional Development Forum. Continuation of Students' Conference.
7.00 p.m.	Consulting Engineers' Annual Dinner.
9.15 p.m.	Muriel's Room.
10.00 p.m.	Entertainment.

Friday, May 27

7.45 a.m.	Authors' breakfast.
9.00 a.m.	Joint ASME – EIC International Council.
2.00 p.m.	Field Trips. Students' Conference — Final session.
6.30 p.m.	Muriel's Room.
7.30 p.m.	Annual Banquet.
10.00 p.m.	Annual Dance.

EIC

the Engineering Institute of Canada

NEWLY ELECTED OFFICERS OF THE INSTITUTE

At the Annual Meeting, three vice-presidents and twenty-four councillors will take office and will serve with others whose terms of office continue. The complete list of Council members will appear in the June issue.

E. A. Cross, M.E.I.C.

Paul G. A. Brault, M.E.I.C.

J. S. Watt, M.E.I.C.

Edgar A. Cross, M.E.I.C., elected vice-president of the Institute representing the Province of Ontario, has been in private practice as a consulting engineer in Toronto since 1930.

Born in England in 1889, Mr. Cross is a graduate in civil engineering of Birmingham University. His carrer has been: assistant engineer, Birmingham Canal Navigations, 1909-15; chemical warfare branch of the British Army in France, 1915-17, research department, Royal Arsenal, Woolwich, 1917-19; chief assistant engineer, Birmingham Canal Navigations, 1919-20; superintendent on construction for W. L. Stoddart, Architect, N.Y.C., 1920-22; designing structural engineer for Albert Kahn, Architect, Detroit, 1922-27, and for Chapman & Oxley, Architects, Toronto, 1927-30.

Mr. Cross is a Member of the Association of Professional Engineers of Ontario and the American Society of Civil Engineers; a Past Councillor for the Institution of Civil Engineers, Great Britain; and a Past President of the Association of Consulting Engineers of Canada.

Charles Miller, M.E.I.C., has been elected vice-president of the Institute representing the Province of Quebec. Mr. Miller is general manager of the Manicouagan Power Company.

Graduating from Queen's University in 1930 in civil engineering, Mr. Miller joined the staff of the Saguenay Power Company at Arvida, Quebec, as draftsman. He became hydraulic engineer and, in 1940, resident engineer. In 1944 Mr. Miller was appointed chief engineer of the Aluminum Power Company. From 1945-47 he was with the Beauharnois Light, Heat and Power Company as general superintendent; from 1947-49 he was chief hydraulic engineer, Ontario Paper Company; from 1949-53, manager of construction for the Manicouagan Power Company's development at the First Falls of the Manicouagan River; from 1953-56, consulting engineer; and from 1957-59, project manager, Canadian British Aluminium Company, Baie Comeau, Quebec. He was appointed general manager of the Manicouagan Power Company in 1959.

Mr. Miller was chairman of the Saguenay Branch of the Institute in 1939.

T. C. Higginson, M.E.I.C., president of Eastward Industries Ltd., Saint John, N.B., has been elected to Council as vice-president of The Institute, representing the Atlantic Provinces.

Mr. Higginson is also Maritime manager of the Automatic Sprinkler Company of Canada, Limited; vice-president and managing director of Country Club Heights Ltd.; and president of the Saint John Board of Trade.

He was born and educated in Montreal. Mr. Higginson joined the Automatic Sprinkler Company of Canada in 1928 and became manager of their interests in the Maritimes in 1946. At the same time he formed Eastward Industries Ltd., and in 1952 he entered the housing and development field.

P. G. A. Brault, M.E.I.C., chief engineer of the Dominion Bridge Company, Ltd., is the Councillor-elect for the Montreal Branch.

A graduate of McGill University in 1921 with a B.Sc. degree, Mr. Brault joined the structural design division of the Dominion Bridge Company in 1926. Loaned to United Shipyards with responsibility for the design of cargo vessel launching arrangements in 1942, Mr. Brault returned to Dominion Bridge in 1945 as assistant to the design engineer. In 1951 he was appointed design engineer; in 1958, assistant chief engineer, Eastern division; and in 1959, chief engineer, structural division, Montreal. In recent years Mr. Brault has been associated with construction of the Halifax-Dartmouth Bridge, the Queen Elizabeth Hotel and St. Lawrence Seaway bridge alterations in the Montreal area.

Mr. Brault has served on the Montreal Branch executive of the Institute and on various committees.

Roy A. Phillips, M.E.I.C., has been elected a Councillor of the Institute representing the Montreal Branch. He is manager of the marketing, appliance and television receiver department, Canadian General Electric Company, Ltd., Montreal.

Mr. Phillips was born in Vancouver and received his B.A.Sc. degree from the University of British Columbia in 1939. Joining Canadian General Electric on their test course immediately upon graduation, Mr. Phillips was an engineer in the switchgear department from 1940-49. He then became works' engineer, Montreal works, and in 1952 was appointed manager, product planning and marketing research, major appliance department. When the major appliance department became the appliance and television receiver department in 1955, Mr. Phillips was appointed manager, product planning and marketing research, of the reconstituted department. He was named to his present position in 1958.

Active in the Canadian Electrical Manufacturers Association and an elected officer of the Corporation of Professional Engineers from 1952-56, Mr. Phillips has served the Institute in several elected offices and is currently chairman of the Montreal Branch.

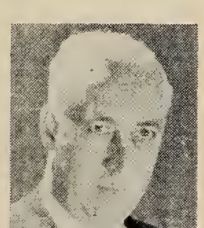
John S. Watt, M.E.I.C., has been elected to represent the Ottawa Branch of the Institute on Council. He is on the staff of the headquarters engineering department, National Harbours Board, Ottawa.

A graduate of the University of New Brunswick in 1943, with a B.Sc. degree in civil engineering, Mr. Watt began his engineering practice on foreign contract to the Bahrein Petroleum Company where he worked on refinery construction in the research and development department. Returning to Canada, he worked in the engineering department of Imperial Oil, Montreal East refinery. Since 1947 he has been employed by the National Harbours Board, working on design of marine structures with the headquarters engineering staff in Ottawa.

A past chairman of the Ottawa Junior Section of the Institute and member of the Ottawa Branch executive, Mr. Watt was chairman of the Ottawa Branch in 1959.

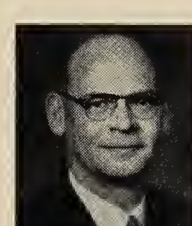
A. C. Davidson, M.E.I.C., is the Councillor-elect from the Toronto Branch of the Institute. Mr. Davidson is an assistant professor in the department of civil engineering at the University of Toronto and the Past Chairman of the Toronto Branch of the Institute.

He graduated from the University of

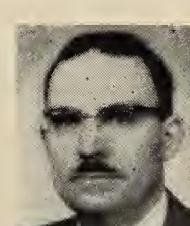


C. Miller, M.E.I.C.

T. C. Higginson, M.E.I.C.



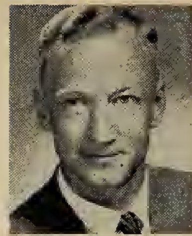
R. A. Phillips, M.E.I.C.



A. C. Davidson, M.E.I.C.

Manitoba with two degrees, one in civil engineering and one in electrical engineering, and received his Master of Applied Science from the University of Toronto. During the last war Mr. Davidson served with the Royal Canadian Engineers at National Defence Headquarters in Ottawa, directing the purchase of equipment and supervising research projects. His civilian experience includes: work with Dominion Bridge on design and erection of steel structures; design of steel frames for large power houses, Hydro Electric Power Commission of Ontario and Brazilian Service Limited; design of concrete structures for Yonge St. subway, Toronto Transit Commission; buildings, housing and municipal services, Defense Construction and Central Mortgage and Housing Corporation; and work on the microwave relay line across Newfoundland, Canadian National Telegraphs.

W. G. Heslop, M.E.I.C.



S. R. Sinclair, M.E.I.C.

R. D. Livingstone, M.E.I.C.

W. G. Heslop, M.E.I.C., has been elected to represent the Vancouver Branch of the Institute on Council. Mr. Heslop has been associated with the University of British Columbia since 1945 and is at present an associate professor of civil engineering. He is also employed by Morrin & Knutson Construction Engineering at Kenamo, B. C.

After graduation from the University of Toronto in 1930, civil engineering with hydraulic option, Mr. Heslop worked in the transmission department of Ontario Hydro and the Department of Highways of Ontario doing location and construction work. From 1935-40 he was employed by Hollinger Consolidated Gold Mines on underground ventilation and silicosis prevention. During the war, 1940-45, he served in the Royal Canadian Air Force supervising navigation training under the Empire Air Training Plan in Canada.

Since joining the University of B.C. faculty in 1945, Mr. Heslop has worked with H. G. Acres & Co., 1946; the Fraser River Dyking Board, 1948; B.C. International Engineering, 1949; and Morrin & Knutson, since 1951.

Mr. Heslop is an Associate Member of the Canadian Institute of Mining and Metallurgy.

Stewart R. Sinclair, M.E.I.C., of Edmonton, professor and head of the civil engineering department, University of Alberta, has been elected to serve as Councillor for the Institute, representing the Edmonton Branch. He is the Immediate Past Chairman of the Branch.

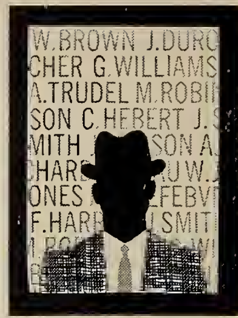
Mr. Sinclair is a graduate in civil engineering from the University of Alberta, B.Sc. 1944, M.Sc. 1947. He joined the staff of the University of Alberta in 1947 and took over his present position in 1959. He also serves as a consultant in the fields of soil mechanics, highways and foundations.

R. D. Livingstone, M.E.I.C., general manager of Lethbridge Collieries, Ltd., has been elected to the Council of the Institute as representative from the Lethbridge Branch.

Graduating with a B.Sc. in mining engineering in 1939 from the University of Alberta, Mr. Livingstone worked underground for the next two years to gain his Mine Manager's and Surveyor's papers under the Alberta Mines Act. From 1941-45 he served with the Royal Canadian Engineers and was twice decorated. After the war Mr. Livingstone returned to Lethbridge and was employed as mining engineer and manager until 1956 when he was promoted to

(Continued on page 125)

Personals



A. O. Dufresne, M.E.I.C. (Ecole Polytechnique '11), Deputy Minister of Mines for the Province of Quebec, retired April 1, after 45 years' association with that department.

James M. Wardle, M.E.I.C. (Queen's '12) is a member of the National Capital Commission, Ottawa.

W. E. Stone, M.E.I.C. has been transferred to Toronto to open up an office there for Western Reinforcing Steel Services Ltd. as manager of the Company's Ontario division.

A. W. Manby, M.E.I.C. (Michigan '21) has retired from the post of general manager of the Ontario Hydro-Electric Power Commission.

John W. Hackney, M.E.I.C. (Carnegie Institute of Technology '34) has been appointed vice-president of Beaco Limited's process plant divisions across the country.

W. P. Nesbitt, M.E.I.C. (Queen's '35) has been appointed general manager of the pulp and paper division of Howard Smith Paper Mills Ltd.

William H. Stuart, M.E.I.C. has been in the United States for the past year as Manager of the New York Office of A. D. Margison and Associates, Consulting Engineers, for Canada on matters relating to certain aspects of U.S.-Canada Joint Defence.

John Terry, M.E.I.C. (Calcutta '48) has been appointed assistant mechanical engineer of Dosco's coal operations.

Roy F. E. Bunston, M.E.I.C. (Queen's '42) has been appointed vice-president and general manager of M & M Line Construction Co. Ltd.

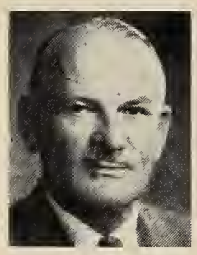
Philip M. Meis, M.E.I.C. (Manitoba '43) has been made western region manager for Honeywell Controls Ltd. The post is newly created.

H. A. Marshall, M.E.I.C. (Nova Scotia Technical '43) is the chairman of the Halifax Branch of the Institute. He is manager of consumer sales for Imperial Oil Ltd.

Stanley W. Pappius, M.E.I.C. (Royal Naval Engineering College, U.K. '45) has been appointed sales manager of the mechanical division of Dominion Bridge Company, Ltd. He was formerly associated with Canadian Vickers, Ltd.

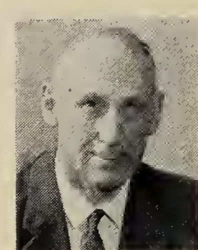
W. Lloyd Sharpe, M.E.I.C. (Saskatchewan '47), city engineer of Weyburn, Sask., is the new president of the Western Canada Water and Sewage Conference.

R. F. Harris, M.E.I.C. (Toronto '49) has been elected president of the Builders' Exchange of the City of London, Ontario for the year 1960. He is district manager of The Foundation Company of Ontario's London office.



A. W. Manby, M.E.I.C.

H. J. A. Chambers, M.E.I.C.



R. Hobner, M.E.I.C.

F. L. West, M.E.I.C. (McGill '16) has been granted a life membership in the American Society of Civil Engineers. Mr. West is vice-president of Mount Allison University, Sackville, N.B.

H. C. M. Gordon, M.E.I.C. (McGill '23) has been appointed vice-president of The Dominion Steel and Coal Corporation's mining operations. He is also vice-president and general manager of Dosco's Dominion Coal Company.

Roland R. Duquette, M.E.I.C. (Ecole Polytechnique '32) was recently elected president of the Association of Consulting Engineers of Canada.

Georges Demers, M.E.I.C. (Ecole Polytechnique '35), consulting engineer at Quebec City, has been elected president of the Association of Graduates of Ecole Polytechnique.

Harold J. A. Chambers, M.E.I.C. (Toronto '24) has been appointed president of Fluid Power Ltd., Toronto, a newly incorporated company.

R. E. Grout, M.E.I.C. (Alberta '36) has been appointed a vice-president of The Shawinigan Engineering Company Ltd. He was formerly chief engineer, electrical division.

Robert H. Hobner, M.E.I.C. (Manitoba '35) is project engineer with the Northern Construction Division of the Department of Public Works' building construction branch.

Nelson S. Hepburn, M.E.I.C. (British Columbia '50) has been appointed a director of A. B. Sanderson and Company Ltd. He is Chief Engineer of the firm and manager of the Vancouver office.

H. W. Percival JR.E.I.C. (McGill '50) has accepted a position as project engineer with the Aluminum Company of Canada, Arvida, Quebec.

J. C. J. Heroux, JR.E.I.C. (McGill '52) formerly employed by the Public Works Department of Canada, in Montreal (harbours and rivers branch) is now town engineer for Shawinigan South, Quebec.

Donald R. Evans, JR.E.I.C. (Toronto '53) has been appointed city engineer of Sault Ste. Marie, Ont. He was formerly a project engineer with Marshall Macklin Monoghan Ltd., Don Mills, Ont.

N. B. Breen, JR.E.I.C. (Saskatchewan '49) has left the Canadian Locomotive Company and is now associated with Aluminium Laboratories Ltd. in Kingston, Ont., as service welding engineer.

N. R. Breen, JR.E.I.C.

W. Strok, M.E.I.C.

W. Strok, M.E.I.C. (Durham '55) has become a Professional Engineer of the Province of British Columbia.

I. Waterlow, M.E.I.C. (McGill '51) recently took over the position of superintendent of Maintenance Yards and Services for Cominco at Trail, B.C.

R. Donald Emmett, JR.E.I.C. (Toronto '51) has opened an electrical consulting practice in the Toronto area. He has been in architectural and industrial electrical design and supervision work.

R. D. Emmett, JR.E.I.C.

S. R. Mester, JR.E.I.C.

S. R. Mester, JR.E.I.C. (McGill '57) has been appointed sales manager for Needco Cooling Semiconductors Ltd., Montreal, a new Canadian company.

Melvin J. Shelley, M.E.I.C. (British Columbia '55), former city engineer of the City of Vernon, has accepted a position as city engineer of Moose Jaw, Sask. He leaves his post as chairman of the Central B.C. Branch of the Institute.

O. M. Hodgkins, S.E.I.C. (Toronto '59) has accepted a position as construction engineering officer in the RCAF at Lac St. Denis.

● OFFICERS

(Continued from page 120)

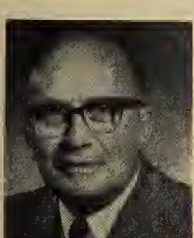
his present position. He served on the council of the Association of Professional Engineers of Alberta from 1953-56 and has been a member of the joint finance, discipline and investigations, meeting, and membership and enforcement committees.

Mr. Livingstone is a past chairman of the Lethbridge Branch of the Institute. In 1952 he served as national chairman of the coal division, Canadian Institute of Mining and Metallurgy. He is also a member of the Institute of Mining Engineers of Great Britain and the American Institute of Mining Engineers. Continuing to be active in the Royal Canadian Engineers' Militia, Mr. Livingstone is the Commanding Officer of the 8th Field Engineer Regiment, with the rank of Lieutenant Colonel.

W. G. Sharp, M.E.I.C., is the Councillor-elect for the Calgary Branch of the Institute. He has been on the executive of the Calgary Branch and served as its chairman in 1954-55.

Since graduation from the University of Alberta in 1933, with a B.Sc. in electrical engineering, Mr. Sharp has been engaged in the theatre supply business. In the early years Mr. Sharp's interest was mainly in installation and servicing of motion picture projection and sound equipment and in the latter years it has been in the administration and operation of his own business, Sharp's Theatre Supplies, Ltd.

Mr. Sharp is a member of the Association of Professional Engineers of Alberta.



W. G. Sharp, M.E.I.C.

J. L. Thompson, M.E.I.C.

J. L. Thompson, M.E.I.C., has been elected to Council to represent the Saskatchewan Branch of the Institute. He is head of the agricultural engineering section, Canada Department of Agriculture, research branch, experimental farm, at Swift Current, Saskatchewan.

Holding degrees from the University of Saskatchewan (B.E. in agricultural engineering, 1938) and Iowa State College (M.Sc. in agricultural engineering, 1948), Mr. Thompson worked from 1938-47 as irrigation supervisor for Canada Department of Agriculture at Swift Current, preparing agricultural lands for irrigation on new projects being developed by P.F.R.A. In 1948 he transferred to the research field doing power and tillage studies on agricultural equipment with the Experimental Farm. Mr. Thompson accepted his present position in 1950.

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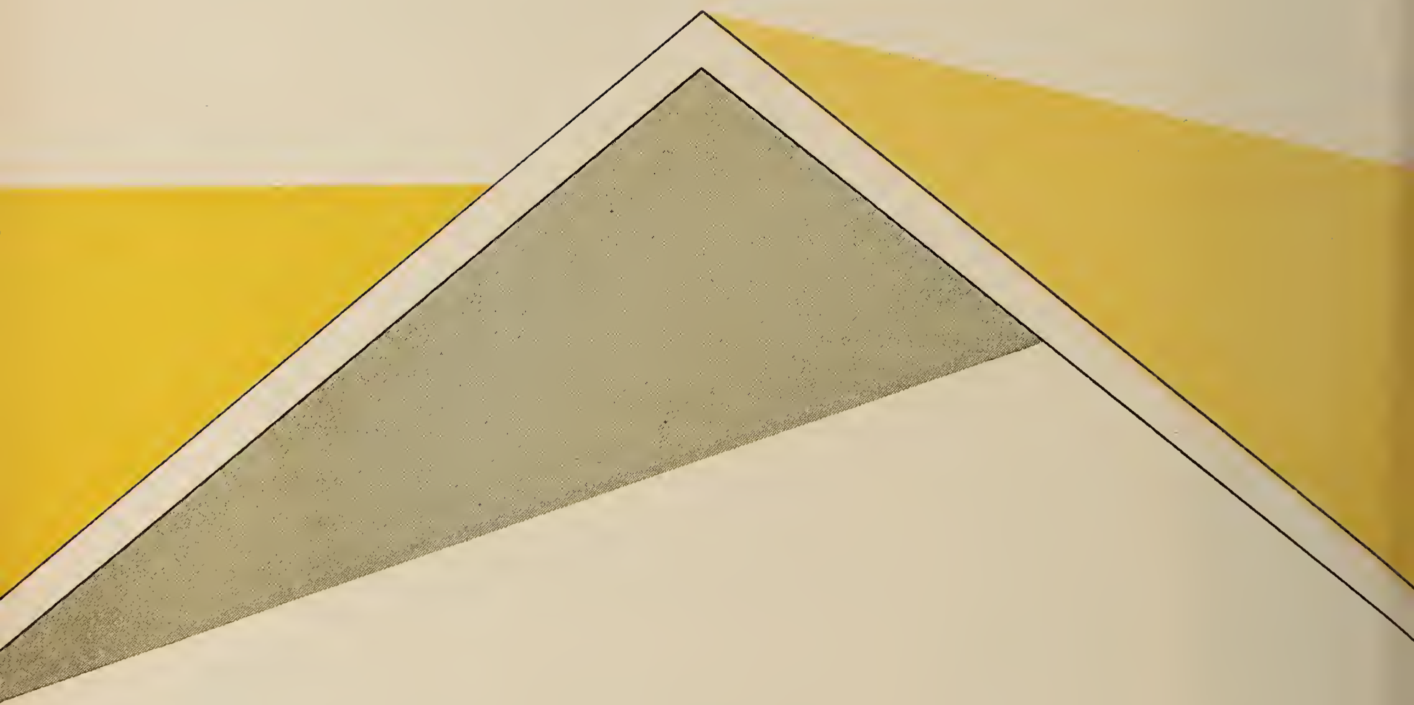
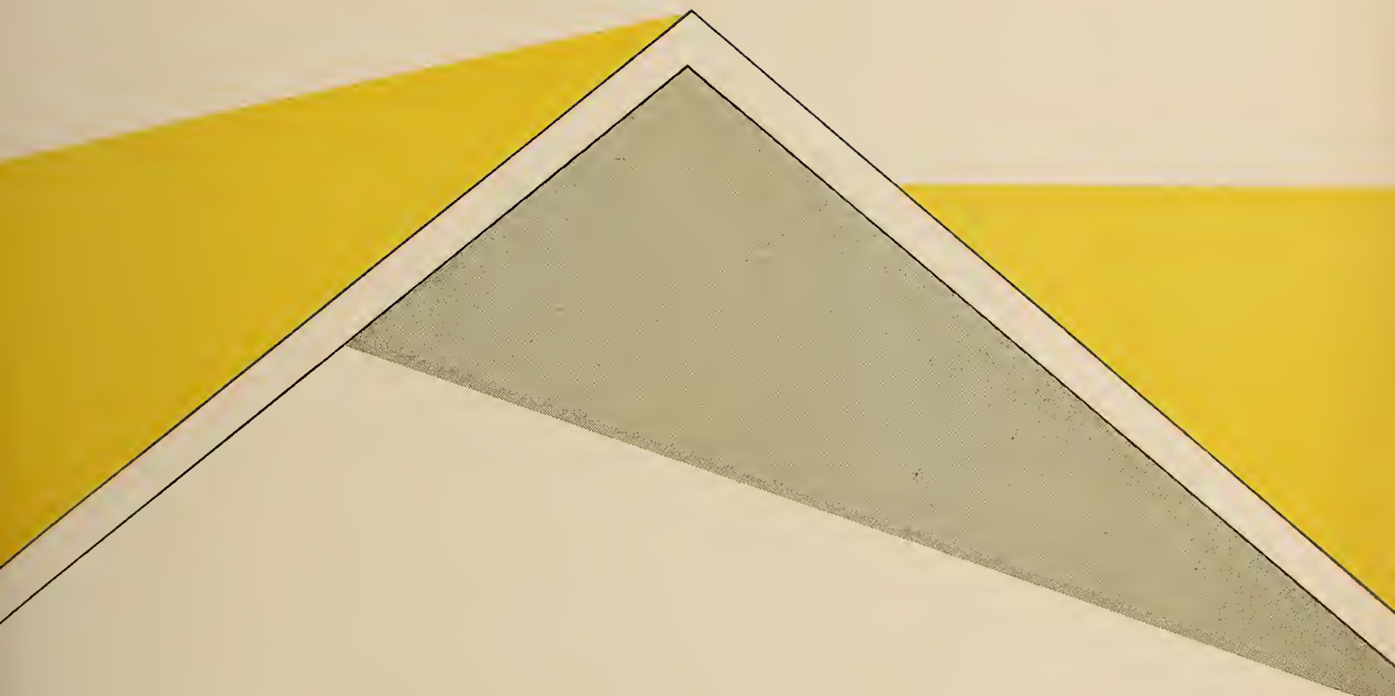




• OFFICERS

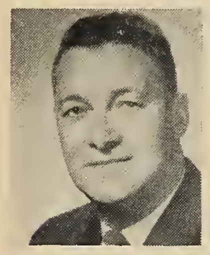
(Continued from page 125)

N. S. Bubbis, M.E.I.C.

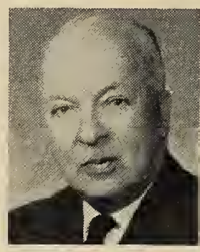
N. S. Bubbis, M.E.I.C., has been elected Councillor for the Winnipeg Branch of the Institute. He is general manager and chief engineer for the Greater Winnipeg Water and Sanitary Districts.

A graduate in civil engineering from the University of Manitoba, 1934, Mr. Bubbis started work with the City of Winnipeg as a pipe plant inspector. He transferred to the drafting and designing branch, where he was later promoted to engineer in charge. In 1944 he was promoted to engineer of water works and sewerage and held that position until 1949 when he became general manager and chief engineer.

Mr. Bubbis is a past president of the Association of Professional Engineers of the Province of Manitoba, of the Canadian Institute on Sewage & Sanitation, of the Western Canada Water & Sewage Conference and of the Minnesota Section of the American Water Works Association. He is a diplomate of the American Society of Civil Engineers, a member of the American Water Works Association, the Federation of Sewage & Industrial Wastes Association, the American Public Works Association and the American Academy of Sanitary Engineers.



W. M. Hogg, M.E.I.C.



F. Alport, M.E.I.C.

W. A. Dawson, M.E.I.C.

William MacDougall Hogg, M.E.I.C., president and director of Great Lakes Power Corporation Ltd., and Great Lakes Power Company, Ltd., has been elected to the Council of the Institute to represent the Sault Ste. Marie Branch.

Mr. Hogg received his B.A.Sc. from the University of Toronto in 1939. Prior to graduation he was with Ontario Hydro as surveyor and engineer on survey and construction work throughout Ontario. In 1939 he became a design engineer with Ontario Hydro and in 1946, project engineer. In 1949 he was senior resident engineer, Des Joachims Power Development; 1951, field project engineer, Sir Adam Beck Power Development and 1954, St. Lawrence Power Development. In 1957 Mr. Hogg joined Great Lakes Power Corporation, Ltd., as vice-president and chief engineer. At present he is its president and director and is also director of The Lake Superior Power Company.

He is a member of the Association of Professional Engineers of Ontario and of the executive of the American Society for Metals. Mr. Hogg is also vice-president and director of the Sault Ste. Marie Chamber of Commerce and a member of the Sault Ste. Marie Industrial Committee.

Frederic Alport, M.E.I.C., has been elected to represent the Huronia Branch of the Institute on Council. Mr. Alport is a consulting engineer at Orillia, Ontario.

A graduate of Orillia Collegiate Institute and the University of Toronto, Mr. Alport received his B.Sc. in 1913. During the summers 1903-06 he worked with the C.P.R. on railroad location and construction on the Prairies and in B.C. In 1906 he transferred to the National Transcontinental Railway, District F, on preliminary and location surveys and construction. He completed Dominion and Manitoba examinations as land surveyor. From 1914-19 Mr. Alport was with the Canadian Corps in France and in 1918 he joined the staff of the 4th Brigade Engineers. In the years 1920-21 he worked with Holbrook, Cabot and Rollins Corporation in Detroit on construction, and in 1924 began a twelve-year term with Patrick McGovern Inc. as contractor. In 1934 Mr. Alport took the position of superintendent on road construction with Curren & Briggs, Ontario, and in 1935 he began work with the Department of Public Works of Canada in Toronto, transferring to the Halifax office in 1938. Working on design of docks for the Canadian Navy from 1939 on, Mr. Alport was transferred to Naval Headquarters in Ottawa as consulting engineer, Naval Service, in 1943. He was awarded the O.B.E.

Mr. Alport returned to the Department of Public Works in Canada, Ottawa, in 1945, and resigned in 1957 to open a consulting office in Orillia.

Jack Edward Harris, M.E.I.C., is the Councillor-elect from the Sarnia Branch. Mr. Harris, is district manager of A. Cope & Sons Ltd., general contractors.

J. E. Harris, M.E.I.C.

D. A. Lamont, M.E.I.C.

A graduate of the University of British Columbia, Mr. Harris received his B.A.Sc. in chemical engineering in 1938 and his M.A.Sc. in 1942. From 1942-55 he worked for Dow Chemical of Canada Ltd. as instrument engineer, maintenance superintendent, works engineer, construction manager and engineering manager. Since 1955 he has been district manager of A. Cope & Sons Ltd., general contractors, specializing in roads, sewers and watermains.

Mr. Harris is a member of the Association of Professional Engineers of Ontario.

W. A. Dawson, M.E.I.C., assistant sales manager of The Brown Boggs Foundry and Machine Company Ltd., Hamilton, Ont., has been elected to represent the Hamilton Branch of the Institute on Council.

Mr. Dawson graduated from Queen's University in 1923 with a degree in mechanical engineering. For twelve years he was associated with the Ford Motor Company of Canada in Windsor, advancing from mechanical draftsman to chief tool engineer. Upon leaving Ford he held successive positions with Algoma Steel Corporation, Sault Ste. Marie, as superintendent of shops and foundries; Chrysler Corporation of Canada Limited, Windsor, as plant engineer of their new motor works; E. Long Ltd., Orillia, as plant manager; Otis Elevator Company Ltd., Ordnance Division, Hamilton, as chief planner and chief inspector of Bofors Gun manufacture. Immediately following World War II, Mr. Dawson was associated with the F. F. Barber Machinery Company, division of Massey-Harris Company, Ltd., Toronto, and opened up a sales office at Hamilton. In 1958 he took up his present position.

Mr. Dawson graduated from Queen's University in 1923 with a degree in an active member of the Association of Professional Engineers of Ontario and a past director and national secretary of The American Society of Tool Engineers. He was the charter chairman of their Hamilton Branch in 1941-42. In 1955 he was elected president of the Queen's University Alumni Association and chairman of its board of directors.

D. A. Lamont, M.E.I.C., manager of systems applications engineering in the apparatus department of Canadian General Electric Company, Peterborough, has been elected to represent the Peterborough Branch of the Institute on Council.

A graduate of Queen's University in electrical engineering, 1945, Mr. Lamont joined the Canadian General Electric Co. on their test course in Peterborough and Toronto immediately upon graduation. Leaving the test course, he joined the engineering department in Peterborough and has spent the majority of his time there in the systems application engineering section.

(Continued on page 132)

Obituaries

William Edward Wakefield, M.E.I.C., chief of the division of timber mechanics of the Forest Products Laboratories, Department of Northern Affairs and Resources, until his retirement in 1954, died January 13, 1960. He was 67.

Mr. Wakefield was born at Long Eaton, Derbyshire, England, and graduated in mechanical and electrical engineering from the Derbyshire Institute of Technology in 1914. He joined the Midland Railway as testing engineer upon graduation, but at the outbreak of World War I joined the Sherwood Foresters, later transferring to the Royal Engineers.

Mr. Wakefield came to Canada in 1920 and started a farming venture with his brother near Prince Albert, Saskatchewan. In 1926 he joined the Forest Products Laboratories. During World War II he served as chief of Ottawa's Air Raid Precaution police. He was a member of the NRC sub-committee on wooden aircraft; the associate committee an aeronautical research; and the joint Canada-U.S. mission to the U.K. to study wooden aircraft production methods.

Mr. Wakefield was for a number of years a director of the Professional Institute of Public Service of Canada. He was also active on a number of technical committees of the American Society for Testing Materials.

William Manton Treadgold, M.E.I.C., head of the University of Toronto's civil engineering, surveying and geodesy department for 22 years, died in Toronto on February 17, 1960.

Born in Brampton, Ont., Professor Treadgold received his diploma in civil engineering from the University of Toronto in 1905. He joined the staff of the School of Practical Science the following year as a lecturer in surveying; was appointed assistant professor in 1913; associate professor in 1919; and professor in 1930. In 1931 he became head of the department of civil engineering and held this post until his retirement in 1953 when he was appointed professor emeritus in civil engineering.

During his undergraduate years and for some time after graduation, Professor Treadgold was employed on railway surveys in British Columbia and with the Geodetic Survey of Canada. During the years 1917-19 he was granted leave-of-absence to serve with the Steel Inspection Department of the Ministry of Munitions. Professor Treadgold was active in the consulting engineering and contracting fields throughout his teaching career. For some years he was consultant to the Town of Brampton, and he was director of John Patterson Construction Company Limited and of Patterson Fuel and Supply Limited, both of Brampton. After his retirement,, Professor Treadgold rendered important service on the three-man Engineering Board of Review which advised the Ontario Department of Highways on contractor's claims.

Professor Treadgold was a member of the Association of Professional Engineers of Ontario.

William L. Fraser, M.E.I.C., 65, director of the Ontario Hydro-Electric Power Commission's St. Lawrence Power Project, died in Cornwall on February 19, 1960.

Mr. Fraser was born in Thorburn, N.S., and received his education at Dalhousie and McGill Universities. He served as a lieutenant in the First World War with the Royal Canadian Engineers, and returned to join the staff of C. D. Howe and Company, consulting engineers, at Port Arthur, Ontario.

In the course of his career Mr. Fraser worked as a resident engineer on highway construction in Nova Scotia; a design engineer for the Shawinigan Water and Power Company; a resident engineer for the Nova Scotia Power Commission during the building of the Cowie Falls development; and assistant chief engineer for the Nova Scotia Department of Highways and Public Works.

He joined Ontario Hydro in 1947 as project manager of the Chenaux Development on the Ottawa River and later was appointed project manager of the Sir Adam Beck Niagara Generating Station No. 2 at Queenston, Ont. He was named assistant director of the St. Lawrence project in 1957 and director in 1959.

Mr. Fraser was a member of the Association of Professional Engineers of Ontario.

Wills Maclachlan, M.E.I.C., known for his widely published research work concerning the effect of electric shock on human beings, died February 29, 1960. He was 74.

Before his retirement five years ago, Mr. Maclachlan was head of the Ontario Hydro-Electric Power Commission's employee relations department; a member of the executive staff of the Toronto Hydro Electric System, and secretary-treasurer and engineer of the Electrical Employers Association of Ontario. Mr. Maclachlan was a Life Member of the Institute.

A graduate of the School of Practical Science, University of Toronto, in electrical engineering, 1907, Mr. Maclachlan published a most valuable index of literature on electric shock, international in scope, after his retirement.

Mr. Maclachlan served as general chairman of the American Society of Safety Engineers and the National Safety

• OBITUARIES

Council. He was chairman of the medal awards committee and a member of the accident prevention committee of the Edison Electric Institute, New York; vice-chairman of industrial relations, E.I.C.; and president of the Royal Canadian Institute.

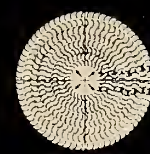
Francis Stuart Lazier, M.E.I.C., consulting engineer of Toronto, died February 23, 1960, at the age of 74.

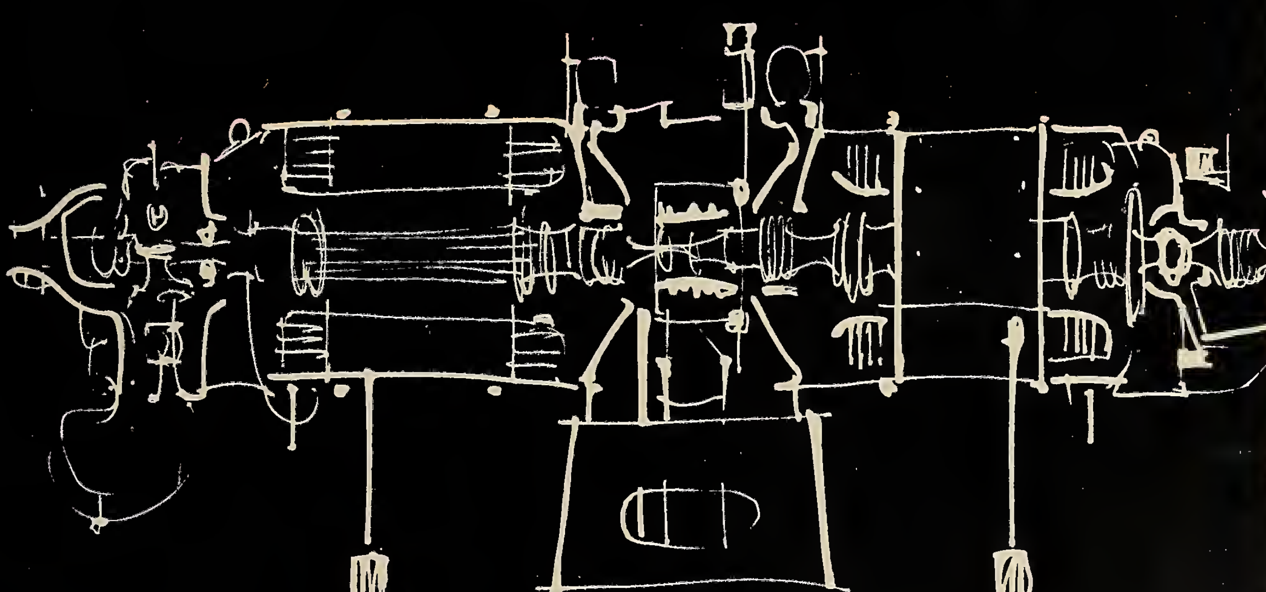
A Life Member of the Institute, Mr. Lazier's career began with railway construction on the Central Ontario, Norfolk & Western, and National Transcontinental Railways. In subsequent years he supervised design and construction of the Trent and Welland Canals. He later was in charge of a power survey of the Madawaska River for Smith, Kerry and Chase, consulting engineers, and was chief engineer and assistant to the president of J. P. Porter & Sons, St. Catharines, Ontario on railway, canal, dredging and harbour projects from the Niagara district to Halifax. As inspecting engineer for the Department of Railways and Canals, Mr. Lazier worked on the Beauharnois Power Development, and later with the National Harbours Board he supervised and reported on construction projects in Quebec and Vancouver harbours.

Born in Charlottesville, Va., Mr. Lazier graduated from Queen's University in civil engineering in 1907. During World War II he became resident engineer for the Allied War Supplies Corporation on construction of explosive and chemical plants at Valleyfield, Que., and of a shell plant at Ajax. Involved in private consulting practice after 1944, Mr. Lazier was Canadian chairman of the International Committee on Yukon River Navigation in 1950 and a member of the Claims Committee for the Department of Highways of Ontario from 1955 to his death.

Hs was a Member of the Association of Professional Engineers of Ontario and The Corporation of Professional Engineers of Quebec.

We regret that our notice of the death of T. M. Lees, M.E.I.C. of Corner Brook, Nfld. made erroneous references to Thomas Lees of Vancouver. Our sincere apologies are offered to Mr. Lees, his relatives and friends for any anxiety this may have caused.





• OFFICERS

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Mr. Lamont has served on the executive of the Peterborough Branch of the Institute for several years and in 1956 acted as branch chairman. A member of the Association of Professional Engineers of Ontario, Mr. Lamont also belongs to the American Institute of Electrical Engineers and the Association of Iron & Steel Engineers.

Bert Thomson Yates, M.E.I.C., is the Councillor-elect from the Cornwall Branch of the Institute. Mr. Yates is a real estate broker in Cornwall.

B. T. Yates, M.E.I.C.

Upon receipt of a B.Sc. from Queen's University in 1917 in civil and chemical engineering, Mr. Yates worked as assistant to the late Dr. "Tilly" Stearn at the Nobel Division of Canadian Explosives Limited. In 1922 he joined the engineering staff of the Abitibi Power and Paper Company Ltd., Iroquois Falls, Ontario, and worked there until 1929, when he returned to Cornwall, Ontario, to run his father's retail business of H. Yates & Co. Ltd. Later he opened his present real estate and brokerage business.

Mr. Yates has served as alderman on the Cornwall City Council and has been a chairman of the Cornwall Branch of the Institute.

G. Demers, M.E.I.C.

F. W. Buckley, M.E.I.C.

Georges Demers, M.E.I.C., consulting engineer in Quebec City, has been elected to Council from the Quebec Branch.

Mr. Demers graduated from Ecole Polytechnique, University of Montreal, in civil engineering and studied subsequently at the Ecole Nationale des Ponts et Chaussees in Paris. In 1935 he became resident engineer, Road Department, Riviere du Loup, Quebec, and in 1936, division engineer for the Roads Department, Carleton, Quebec. In 1938 he was division engineer in the Roads Department, Sherbrooke, Quebec, and the following year was employed as senior design engineer by Z. Langlais, Quebec City. Since 1942 Mr. Demers has had his own consulting practice in Quebec City. He was a professor at Laval University in 1954. In 1955 Mr. Demers was a member of the Joint Commission of the Federal Government and Consulting Engineers on Maritime and Waterways Engineering.

Mr. Demers is a member of the Society of Industrial and Cost Accountants, the Corporation of Professional Engineers of Quebec, the Association of Consulting Engineers of Canada, the American Waterworks Association, the Canadian Institute of Sewage and Sanitation, the Association Internationale des Ponts et Charpents, the Sociéte des Ingenieurs Civils de France, the American Society of Civil Engineers, and the Federation Internationale de la Precontrainte.

Mr. Demers was president of the Corporation of Professional Engineers of Quebec in 1954 and president of the Dominion Council of Professional Engineers in 1955. He is at present on the council of the Association of Consulting Engineers of Canada.

Frederick William Buckley, M.E.I.C., is the Councillor-elect from the Northern New Brunswick Branch. Mr. Buckley is chief engineer at the Bathurst Power & Paper Company, Ltd.

A graduate in electrical engineering from Mount Allison University and Nova Scotia Technical College, Mr. Buckley joined the Nova Scotia Power Commission in 1938 as a field engineer on ransmission and distribution line location. In 1941 he became design engineer on steam and hydro plant design and in 1947 he joined the Bathurst Power & Paper Company Ltd. as design engineer, becoming chief engineer in 1950.

Mr. Buckley is a member of the Association of Professional Engineers of New Brunswick.

C. L. Trenholme, M.E.I.C.

C. L. Trenholm, M.E.I.C., district engineer in the Maritime and Newfoundland areas for Alchem Ltd., has been elected to Council to represent the Moncton Branch of the Institute.

Mr. Trenholm is a graduate of Nova Scotia Technical College, mechanical engineering, 1944. After serving with the Royal Canadian Electrical and Mechanical Engineers in World War II, he joined the New Brunswick International Paper Company. In 1947 Mr. Trenholm took a position with Alchem Limited, Burlington, Ontario, and has been with them since, acting now as district engineer with offices in Moncton.

He served as chairman of the Moncton Branch of the Institute in 1958-59.


C. V. Campbell, M.E.I.C.


J. D. Kline, M.E.I.C.


W. A. MacDonald, M.E.I.C.


P. E. Buss, M.E.I.C.


L. J. R. Sanders, M.E.I.C.

C. V. Campbell, M.E.I.C., has been elected to represent the North Nova Scotia Branch of the Institute on Council.

Mr. Campbell received his pre-engineering education at St. Francis Xavier University, Antigonish, Nova Scotia, and his bachelor of engineering from Nova Scotia Technical College.

He is vice-president of I. Matheson & Company, Limited, New Glasgow, N.S.

J. D. Kline, M.E.I.C., has been elected to represent the Halifax Branch of the Institute on Council. He is general manager of the Public Service Commission of the City of Halifax.

Educated at St. Mary's University and Nova Scotia Technical College, Mr. Kline received his B.Sc. in 1938 and a B.E. in civil engineering in 1940. Following graduation he was employed by Defence Industries Ltd., a Crown Corporation engaged in munitions production. During 1940-41 he worked as a draftsman in Montreal on structural and mechanical design of shell-filling plants. He was transferred to the Pickering Works in Ajax, Ontario, in 1941, as field engineer and in the next three years was successively assistant construction superintendent, project engineer and design engineer. Returning to Halifax in 1944, Mr. Kline took up the position of design engineer in the newly formed Public Service Commission. He became chief engineer in 1947, assistant manager in 1954, and general manager in 1958.

Mr. Kline has been active in the Association of Professional Engineers of Nova Scotia as secretary-treasurer-registrar from 1946-54, a member of council in 1957, and vice-president in 1958. He served as secretary-treasurer of the Halifax Branch of the Institute from 1946-48 and as chairman of the branch in 1958. He is currently the vice-chairman of the Canadian Section of the American Water Works Association.

W. A. MacDonald, M.E.I.C., manager of the Seaboard Power Corporation Ltd., is the Councillor-elect from the Cape Breton Branch of the Institute.

Mr. MacDonald graduated from Mount Allison University, with an engineering certificate, in 1927, and from Nova Scotia Technical College, with a degree in electrical engineering, in 1929. After five years of service with the Northern Electric Company, Montreal, and the Nova Scotia Department of Highways, Mr. MacDonald began working for the Dominion Steel and Coal Corporation in 1934, and, following a brief term at International Piers on special assignment, became a member of Dosco's electrical staff. In 1942 Mr. MacDonald was appointed field engineer and in 1956 he took over his present post.

He is a member of the Registered Professional Engineers Association of Nova Scotia and also of the Mining Society of Nova Scotia.

Paul E. Buss, M.E.I.C., has been elected to represent the Niagara Peninsula Branch on the Council of the Institute. Mr. Buss is president of Spun Rock Wools Limited, Thorold, Ontario. This will be Mr. Buss's eighth consecutive term on the council.

A graduate of the University of Michigan with a B.Sc. in electrical engineering, Mr. Buss joined the engineering staff of Provincial Paper Ltd. as a plant engineer, Thorold division, after overseas service with the United States Army Engineers in World War I. He was also associated with the Dominion Engineering Works. During 1932-33 Mr. Buss and his brothers experimented in a new process for producing wool by the spinning method. Soon afterward Mr. Buss set up the firm Spun Rock Wools Limited, at Thorold, of which he is president.

Mr. Buss was secretary-treasurer of the Niagara Peninsula Branch in 1931 and chairman in 1935. He recently retired from the Thorold Board of Trade after twenty years' service as secretary-manager.

L. J. R. Sanders, M.E.I.C., president and managing director of the L. J. R. Sanders Engineering Company, Galt, Ontario, has been elected to serve on the Council of the Institute as representative from the Kitchener Branch.

Mr. Sanders is a graduate of Loughborough College, England, 1923, with a degree in mechanical engineering. He began his engineering training with the Westinghouse Company in England. After post-graduate work at Cornell University, Mr. Sanders went to work with Tudhope Anderson in Orillia, Ont., as chief engineer, and later with Lake Shore Mines at Kirkland Lake, Ont. In 1929 he joined the Aluminum Company of Canada as divisional superintendent in Toronto. After a few years as a consultant in machine shop and foundry practice in the United States and Canada, he joined the Algoma Steel Corporation, Sault Ste. Marie as superintendent of shops. In 1940 he was one of those to go to England with a group from the Otis Elevator Company to study the Bofors gun. Mr. Sanders joined the Wartime Merchant Shipping in 1941 and was eventually made director of naval stores in Ottawa. At war's end Mr. Sanders purchased the C. H. Smith Machine Company in Galt and founded the organization which he now heads.

A charter member of the Kitchener Branch, Mr. Sanders was chairman of the branch in 1955.

● MONTH TO MONTH

(Continued from page 114)

6) Support measures for adequate water supplies, sewage disposal and conservation of natural resources.
7) Co-operate with Boards of Trade or similar public bodies interested in civic, provincial or federal planning.
8) Give greater publicity to engineering meetings, addresses by engineers, important engineering achievements, etc.
9) Encourage engineers to write letters to newspapers when they have a sound opinion to express.

M. P. Whelen, M.E.I.C.
P. F. Peele, M.E.I.C.
L. J. R. Sanders, M.E.I.C.

Athlone Fellowships

The British Government awards 38 Athlone Fellowships annually to enable Canadians who have earned an engineering degree in Canada to further their studies in the U.K. Twenty-eight fellowships are offered for graduates on completion of a bachelor's or higher degree; the other 10 fellowships are for engineers who have already spent some time in industry. Awarded for a two-year period, the Athlone Fellowships can be used for works training in one or more approved industrial organizations; for post-graduate studies in a U.K. university, college or research establishment; for a combination of these; or for research in a U.K. university toward the degrees of M.Sc. or Ph.D.

The Athlone Fellowships Scheme for the Practical Training in Industry of Canadian Engineering Graduates in Great Britain has been in operation since 1950. Its primary objective has been, and is, to familiarize Canadian engineering graduates with British industry, and thus the emphasis of the fellowship scheme is on the works program. Attention is given to geographical distribution in selection of candidates and the fellowships are apportioned to all Canadian universities having engineering faculties.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on December 18, 1959.

Member: G. H. Barrett, Montreal; T. L. Batke, Kitchener: R. B. Campbell, Ottawa; S. L. Carter, Calgary; K. A. Downie, Vancouver; H. Fennerty, Toronto; A. B. Fraser, Fort Smith; D. Gardner, Calgary; F. Green, Montreal; J. W. Hackney, Montreal; R. Hamelin, Montreal; J. C. Hanbury, Prince George; E. Henye, Montreal; L. G. W. Jarvis, Sudbury; K. R. Kettlewell, Edmonton; F. Lafranco, Sept Iles; R. I. MacDormand, Montreal; J. G. Macpherson, Niagara Falls; B. R. Myers, Waterloo, Ont.; A. G. Osborne, Sudbury; N. D. Pappas, Toronto; J. A. Rice, Vancouver; H. W. Sisson, Edmonton; E. J. Taylor, Montreal; W. H. Vermillion, Montreal; J. H. Wright, Vancouver; C. G. Zimmerman, Galt.
Junior: E. B. Davies, Halifax; M. F. C. Emmett, Brockville; J. Froggatt, Hamilton; W. Gibian, Montreal; W. W. J. McHugh, Montreal; B. J. Thorn, Kapuskasing.

Affiliate: J. T. Davis, Ottawa.

Junior to Member: A. H. Austin, Guelph; J. A. Cowlin, Victoria; G. N. Farantatos, Toronto; K. A. Henry, Cornwall; H. G. Marshall, Port Arthur; W. N. Meikle, Waterloo, Ont.; G. M. Severin, Toronto; D. M. Shook, Calgary; I. M. Squire, Montreal; R. S. Taylor, Richmond, B.C.; J. D. Tudor, Vancouver.

STUDENTS ADMITTED

University of British Columbia: M. Ambach, R. L. P. Applewhite, F. J. Arnold, B. E. Backler, K. J. Barlow, R. Bartel, D. K. Bell, J. P. Berdusco, S. P. Betts, D. E. Beynon, D. L. Bridsall, C. M. Blackburn, K. Blower, G. N. Booth, G. W. Brothers, D. J. Buckland, D. W. Burnham, B. M. Burns, R. E. Butler, R. W. Card, E. T. H. Cardey, G. A. B. Catherwood, T. L. P. Chan, V. L. Chong, W. T. Chu, F. S. Chute, W. A. Coles, B. J. Collins, W. S. Corless, B. S. Cowie, E. W. Craft, M. A. Cronie, M. A. Cross, R. F. Cross, R. R. Culbert, J. A. Davies, R. F. Davis, P. M. Dickie, G. E. Dirom, K. F. Dobell, N. A. R. Douglas, E. J. Dubberley, D. C. Duff, N. H. Dulson, N. J. Duncan, N. A. Eckstein, R. D. Effa, J. S. Elliott, J. G. Farstad, I. B. Foulks, P. R. N. Felker, A. E. J. Ferrie, J. D. Flynn, J. K. Foster, N. R. Fowler, B. F. Garrood, T. B. Gibson, T. M. Gordon, A. D. Gosman, F. A. Graham, B. Gregory, T. L. Guest, D. O. Gurel, T. W. Guthrie, R. W. J. Hahn, T. M. Hamaguchi, P. W. T. Hamilton, R. A. Hamson, W. H. R. Hellwig, E. D. Hetherington, J. G. F. Hoefl, R. D. Hyndman, A. D. Jablonsky, E. Joa, T. G. John, D. G. Johnson, D. H. Johnson, T. W. Johnson, A. S. Y. Jung, K. Kaila, B. Y. B. Kan, D. A. I. Kelly, G. M. Kennelly, S. Khanna, R. Kichler, E. H. Kozuki, W. B. Lange, M. R. Langford, G. J. Lastman, D. B. Lawson, K. Lee, W. W. Lissiman, P. Lo, D. I. Macpherson, B. H. Mansfield, R. C. Martin, L. Martinson, T. S. Mathieson, J. H. McAusland, R. P. McBean, J. D. McKay, D. C. McKechnie, L. P. McKenzie, C. W. McLachlan, G. W. Megaw, K. E. Meissner, T. L. Miletich, H. K. Mittal, R. C. Molina, L. M. Mottu, R. Y. Mukai, D. C. Mulder, H. E. Mulzet, G. Z. Nagy, H. J. Neumann, H. D. Ney, M. D. Olson, J. O'Rourke, N. E. Paget, R. Parker, F. L. Parkinson, M. H. W. Pau, R. L. Pettil, R. H. D. Philp, P. V. Picha, P. Piry, E. Plett, R. A. Ploc, W. W. Plotnikoff, M. Porkolab, I. C. Pratt, J. W. G. Quail, R. G. Ratzlaff, D. J. W. Reid, W. Rempel, J. L. Riddell, D. W. Roberts, J. D. R. Robinson, P. P. Roller, R. A. Rusch, E. T. Ryujin, G. A. T. Salama, D. L. Saxton, R. G. Schaad, G. D. Schildt, A. J. Schmidt, A. Scott-Moncrieff, T. G. Semadeni, H. Shimizu, R. W. Shindel, D. E. Snead, A. Sokol, E. K. Stanley, A. K. L. Strauss, M. J. Sullivan, R. A. Sutherland, D. Svetic, M. Swan, Y. Tanaka, G. W. Tappay, W. A. Trythall, R. Y. W. U., D. S. Ure, R. W. Volkmann, J. A. Vopicka, B. P. Walker, R. D. Warda, H. J. Webster, K. D. Welch, E. A. West, D. B. Wheatcroft, C. P. White, R. T. White, T. M. White, W. H. White, G. J. Whitten, H. Wiebe, F. W. Wiffen, E. C. Wiklund, H. K. Wong, J. A. Wood, F. H. Wyder, R. A. Yestadt, R. Y. J. Young, M. C. Yu.

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Sir George Williams College: P. W. Baraniuk, I. Baumgarten, R. D. Beddoes, J. L. Bent, J. Blocha Jr., J. Chambers, S. Cheung, B. Cornelius, E. Czyziw, B. H. Davis, H. G. E. Dawe, W. W. Despres, D. M. Driscoll, J. Durity, M. Duquette, S. Epstein, W. R. Falconer, F. R. Feltham, L. H. J. Gendron, W. Gow, R. F. Gowing, K. Ho, H. H. M. Johl, D. R. Johnston, A. Kertcsz, D. G. King, A. Kolada, T. J. Kubow, K. Y. C. Kwok, C. Labbe, G. J. LeBlanc, T. Lee, J. Liebmann, G. Mathezer, T. N. Mocker, H. J. Morissette, T. P. Nanasi, S. Papadopoulos, E. Z. Platups, G. Price, J. J. Prokopin, M. R. Rauder, A. Sicotte, G. Valiquette, C. A. Wentges, Z. Wisniowski, B. J. Wong.

Assumption University: P. H. Alexander, H. A. Arnowitz, L. M. Brennan, C. V. Brunetti, L. L. Carbone, R. J. Caverzan, G. J. Cunningham, R. J. DelCol, M. Dienesch, J. M. Douglas, G. S. Dunlop, P. S. Dunseath, J. S. Elias, L. G. Gale, R. A. M. Gazzola, W. P. Howarth, B. G. Jacques, L. Khoubesserian, L. V. Kubis, L. J. Lanza, J. R. Leishman, J. W. Lindsey, H. Y. Lo, W. G. Lourette, P. R. MacDonald, B. P. MacNeil, G. R. Monforton, D. G. Morrison, L. J. Nethery, E. C. O'Neil, D. J. Peach, A. F. Pflanzner, G. F. Potter, M. W. Prince, W. L. Pulleyblank, J. Ray, D. E. Reuzetti, A. Roberts, I. J. Rodriquez-C., C. C. St. Pierre, D. D. Sbrolla, R. A. Shery, W. N. Sigmund, E. L. Stutz, P. Welacky, B. A. Willaughan, W. C. Wilson, J. Y. L. Yau, Z. J. Zajac.

Memorial University, St. John's, Nfld: G. E. Allen, N. L. Andrews, W. S. Andrews, D. K. Bailey, B. K. Baker, T. P. Beresford, J. H. Brake, W. W. Budgell, K. Burden, J. K. Butt, R. G. Chafe, R. B. Clarke, C. C. Coffen, D. Colbourne, P. G. Cole, T. D. Collett, C. D. Colton, D. A. L. Coombs, W. D. Cooper, J. G. Courage, R. M. Crane, A. G. Crichton, H. L. Davis, H. F. Dawe, D. F. Dinn, J. R. Dinn, H. A. Dwyer, D. Earle, F. A. Edwards, E. D. Fisher, J. G. Fitzgerald, G. G. Gill, R. M. Gosse, N. F. Gover, D. F. Humber, W. R. Kennedy, L. King, T. LeFeuvre, D. C. Marett, G. A. Martin, C. W. May, H. M. Meadus, F. L. Moore, G. A. Myers, Jr., R. J. Neville, J. R. O'Neill, W. E. Pear, L. M. Penney, M. E. H. Pinfold, I. A. Rankin, R. A. Rees, A. V. Sheppard, D. Short, F. G. Squires, J. E. W. Stanley, C. S. Stratton, J. T. Strong, L. G. Sturge, W. L. G. White, G. C. Winsor.

University of Waterloo: H. W. Altmann, R. J. Anglin, F. J. R. Anrep, W. T. Arbic, J. F. Bainbridge, J. C. Beam, G. L. Beebe, R. E. Berthin, P. A. Boughton, R. C. V. Britnell, K. N. A. Christie, D. W. Coutts, D. L. Crosby, J. R. Davies, K. F. Dunmow, R. B. Dymond, L. J. Eskritt, W. C. Farmer, J. W. Fletcher, P. L. Fortney, W. W. Gundry, V. C. Hamacher, R. H. Hanselman, N. J. Hathway, G. L. Hawley, C. L. Heck, R. W. Heintz, R. A. H. Herman, D. W. Hewie, D. B. Hutchinson, D. W. Hutton, R. A. Judd, P. M. Koch, R. J. Koteles, W. L. Kreuder, A. A. Livermore, B. O. Long, J. L. Mason, W. D. McCormack, R. S. McKittrick, R. J. McMurray, R. M. Miller, E. W. Mogk, G. F. Nierlich, I. V. Oliver, W. P. Panagapka, R. T. Pettypiece, G. J. Ramer, J. I. Real, K. A. Reichert, W. L. Rohmer, J. E. Roper, G. E. Ruddle, V. Rudik, A. Ruppert, R. M. Schwandt, A. R. Seabrook, R. A. Sehl, J. H. Shaw, P. E. Siemens, R. J. Spence, G. H. Sterling, D. A. Stewart, R. J. Stoltz, P. Voldner, B. A. Wallgren, N. J. Waterhouse, J. E. Welch, A. Williamson, W. L. Wright, D. C. Younger, R. J. Zanussi.

University of Ottawa: R. M. Allen, G. A. Armbrust, L. Balleux, P. Boutet, J. N. Breton, M. Chartrand, G. Chenier, M. K. Chiu, A. Cyr, W. L. Dick, J. Doire, G. Gerard, D. V. Godin, R. Gomez-Morales, M. B. Guertin, G. J. Guilbault, G. M. Guindon, H. P. Guindon, J. Gutauskas, H. G. Hamelin, G. G. Hart, P. R. Hawtrey, J. G. Jackson, Y. Kirouac, A. Lavigne, R. Legault, J. V. R. R. Lepage, V. Mainville, R. Malcolm, R. C. J. Marshall, A. L. Mattuiz, P. T. McKenna, P. Middlestead, R. Migneron, G. Montreuil, W. E. Murphy, D. D. Myles, F. P. D. Navin, A. Paplauskas-Ramunas, G. H. Paquette, L. R. Paquin, C. Peters, J. P. Proulx, P. C. Quinn, S. F. Ralph, C. M. Reardon, M. E. Rehmer, R. E. Riley, J. B. D. Roy, W. Spekkens, R. Theriault, J. J. Therrien, J. Thivierge, J. Thompson, C. S. C. Tung, Y. Vaillancourt, R. Vinette, G. A. Walsh, C. W. J. Wootton, T. Zeitoun.

McMaster University: G. A. Beaudoin, W. K. Crawford, M. D. Eisthen, R. T. Emery, R. Gray, J. N. Johnston, H. J. O. Lawrence, D. H. Male, J. C. McLellan, G. K. Morris, N. V. Repchull, P. N. Smith, D. R. Tyrrell.

University of Western Ontario: R. Albertins, T. D. Armstrong, A. H. Baigent, R. G. Benbow, R. G. Clutterbuck, J. P. Duffy, D. Fotheringham, J. H. Howard, W. G. James, J. D. MacArthur, E. J. Nishimoto, G. D. Raithby, J. F. Savage, G. C. Setterington, W. C. Turek, P. A. Vellinga.

Canadian Services College: J. G. Allen, J. C. Bauer, G. W. Brown, R. S. Bryant, F. M. Bucknum, J. O. Butler, P. C. Callaway, B. M. Cej, P. C. Clarke, F. A. Dvorak, L. T. C. East, J. H. Findeis, G. E. Gillespie, T. N. A. Jensen, G. A. Kennedy, M. L. M. Kochanski, G. J. Koeller, L. R. Larsen, L. G. P. Lee, J. W. Lowthian, R. P. E. Miners, D. L. L. Mulder, R. L. Rowlatt, R. A. Rutherford, T. C. Rymer, D. G. Stocks, W. J. Taylor, G. L. Walt, R. J. Williams.

St. Dunstan's University: G. L. Coady, H. R. Coles, F. L. Gillis, T. C. Healey, S. C. Jackman, L. Marko, E. V. Mooney, E. J. Nellis, G. W. Pineau, E. J. Power, E. B. Sparkes, R. S. White.

St. Joseph's University: C. Albert, R. J. Albert, H. Allain, P. A J. Arsenault, R. E. Arseneault, J. P. Belliveau, L. M. Bilodeau, J. P. Bourgeois, E. Bourque, H. C. Bourque, C. E. Brison, R. A. Frechet, T. Langis, G. T. LeBlanc, R. T. LeBlanc, Y. G. LeBlanc, J. B. Leger, J. R. Levausseur, P. C. Nadeau, J. D. Saulnier, P. Savoie, Y. Vautour.

Loyola College: T. F. Lee, M. Zadarnowski.

Laval University: R. Dussault.

Mass. Institute of Technology: V. K. Chung.

D. B. Harrison, B.Sc.El. University of Alberta 1959.
P. G. Hodgson, Student, Institution of Electrical Engineers.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective:

ALBERTA

Members: J. E. Armstrong, R. F. Comstock, A. T. Iwasivk, J. P. Verschuren. Junior to Member: K. A. Millions.

SASKATCHEWAN

Members: S. S. Brkich, L. V. Johnson, L. P. Maier, D. H. Maier, D. H. Mode, G. R. Piros, O. Van Bockel, J. F. Wade, J. G. Wotherspoon; Juniors: D. J. Ferguson, L. D. Gerhardt, D. A. Sharp; Students: L. W. Arnst, L. L. Davidoff, J. E. Ellefson, E. J. Ellis, G. A. Martin, R. K. Radford, L. M. Robinson, E. S. Shayna; Junior to Member: W. D. Blue, T. J. Bradshaw, D. E. Cherry, D. L. Dow, E. B. Garrett, R. C. Miller, T. J. Mynihan, H. Pelech, J. R. S. Sadler; Student to Member: J. G. Trotter; Student to Junior: D. D. Baldwin, G. F. Hutch, J. E. McGuire.

NOVA SCOTIA

Members: J. C. S. Campbell, L. E. Powell, D. E. Yeadon; Junior to Member: E. S. Bengston, C. L. Fulton, M. R. McKay, K. C. Scott.

MANITOBA

Member: W. H. Milley, K. L. Philip.

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● DISCUSSION

(Continued from page 103)

fairly large scatter, but showed shear strengths of about 1/2 to 2/3 those evidenced by the field vane. No other strength tests were carried out.

(d) No grain size distribution tests were run.

2. Consolidation Tests

(a) The original five boreholes were put down over an area of about 1000 ft. square, and the tests described above indicated very uniform subsoil conditions indeed. Thus, seven consolidation tests were very carefully carried out to supply results on which the preliminary calculations were based; four of these tests were on soil from the "varved clay" layer, the remainder from the less compressible "varved silty clay". For each test a sample was used which included several varves, in order to obtain average characteristics of the soil as far as possible. Remarkably similar results were obtained for all tests in each soil, and these test results are summarized in an average form in Fig. 3. The tests were carried out on samples obtained at 25 to 27 ft. and 45 to 51 ft. depths. No attempt was made to determine any variation of consolidation properties with depth.

(b) Fig. 3 gives averaged values obtained from consolidation tests at the depths indicated in 2(a) above and water contents and limits can be obtained from any reply to 1(b).

I realize that the number of consolidation tests is small in relation to the area and depth of sediments involved, but it should be borne in mind that the other tests had already indicated an extremely uniform soil profile over the area, that only preliminary estimates were at first required with a view to preloading the site, and that the site investigation was a commercial proposition, and not a laboratory investigation. Much more importance was to be placed on the results of preloading the site as a full-size test rather than on any number of tests carried out in the laboratory on soil disturbed to some degree.

3. Settlement Calculations

(a) The answers to these questions are too long for the limited space at our disposal and will be dealt with more thoroughly in a future paper. Briefly, it was necessary to compute immediate "elastic" and "plastic" settlements in each of the sandy silt, varved clay, and varved silty clay layers. In the first of these, the settlements were estimated from the applied stress and the relative density of the material, considering the tank to be a very wide footing. The results were checked by a search through our files for previously similar situations. Obviously such an estimation is only approximate.

For the varved clay layer, immediate settlements were calculated using Reference (1) and the stress-strain results of laboratory unconfined compression tests. Since the settlement computed this way would be too large owing to the disturbance of the samples and lack of confinement, it was considered that this settlement amount would take into account any deformation of the lower clay layer. Another computation was also carried out using the method of Reference (2) which gave similar results. In this case, the "elastic" moduli used were also taken directly from the unconfined compression since this would include both "elastic" and "plastic" yielding of the soil. As most of the settlement would take place in the upper layer of clay, an average value of modulus of 100,000 p.s.f. was taken for this layer. The value only changed appreciably with depth below a depth of about 50 to 60 ft. All the test samples were composed of many varves.

(b) All settlement calculations were based on results of tests carried out on samples with several varves; no attempt was made to estimate settlements resulting from each type of soil in a varve, as it would be impossible to estimate the total thickness of different soils. Different samples from different varves may also have had differing properties, although average properties remained the same.

For all settlement predictions for the water tests and completed tanks, the results of the preloading settlement measurements were of course used, rather than data from laboratory tests.

References in Discussion

1. Meyerhof, G. G., "The Tilting of a Large Tank on Soft Clay," Proc. of South Wales Inst. of Engineers, April, 1951.
2. Steinbrenner, W., "Tafeln zur Setzungsberechnung," Die Strasse, V. 1, 121-124, 1934.

ENGINEERING FOR EXPORT

R. A. Frigon, M.E.I.C.
Chief, Engineering and Equipment Division, Foreign Trade Service, Department of Trade and Commerce, Ottawa.

The Engineering Journal, 1960, March, p. 93.

Author's Comment on Discussion:

One of the main objectives of my paper was to provoke discussion. I am gratified to note the response in the form of written discussion presented by several consulting engineers having experience in the export of engineering. These discussions come as a welcome supplement to the ideas expressed in my paper. They are proof that Canadian engineers are keenly interested in the subject. I have no other comment except to say that I have found the discussions both verbal and written most valuable and I am encouraged to continue my study of this field.

Discussion by Nicholas Fodor, M.E.I.C.

Mr. Frigon is certainly to be congratulated on his excellent coverage of this most important and very interesting subject. I personally am very much interested in every aspect of this subject 'Engineering for Export' and based on my experiences I am taking the liberty of making a few comments.

1. In my opinion (and I am sure every engineer who has the future and welfare of Canada in his heart will agree), nothing better could be done by us, in the interests and prestige of our country, than the selling of engineering abroad. It is, in effect, the selling of brain products, and what could be finer than that. England is perhaps the best example in this respect; I firmly believe that the greatness of the British Empire resulted to a great extent from just such a program.

2. The engineer who is exporting his brain products is doing it also in his own personal interests. Not only do we all hope for it to be a profitable venture on its own, but also it plays a considerable part on the position of the engineer within his own country's boundaries. Such work will increase immensely his own reputation inside Canada, as there can be no better promotion for any engineering firm than increasing the reputation from the publicity and experience coming from work being well done abroad.

I assume that everyone will agree on the importance of this type of export for all concerned. Therefore it probably follows for me to make some practical suggestions based on my own personal observations.

(a) Perhaps it is unfortunate in many ways, but from a practical point of view it is only being sensible to face the fact that only larger firms can do any effective engineering for export. Admittedly, the selling of engineering abroad involves very expensive trips in the promotional stage where the return is far from assured. Coupled with this fact, and equally important, is the length of absences required from the office.

(b) While I myself, and our firm, are strictly consulting engineers in its purest form, in engineering for export we admit that we have to face somewhat different circumstances. That is in practically all countries where I have had the opportunity in various ways to attempt to do engineering for export, it was obvious

(Continued on page 160)

Other Societies

American Institute of Industrial Engineers To Organize Montreal Chapter

A meeting was held on February 4, 1960, to organize a Montreal chapter of the A.I.I.E. A pro tem executive was elected and membership and constitution committees formed. The seven existing members of the A.I.I.E. met in Montreal on February 23 to discuss the aims and policies of a local chapter and expressed the feeling that such a chapter would best serve the industrial engineering community as a group which "could discuss problems and methods on a high technical level." It would complement rather than compete with other organizations in the area.

Toronto Quality Control Society

The Toronto Section of the American Society for Quality Control has scheduled meetings for May 4 and 18. The first is to be a lecture by Mary N. Torrey, Bell Telephone Laboratories, New York, on "Selection of Samples for a Purpose" and will be held in the electrical engineering building, University of Toronto, at 8 p.m. On May 18 members and guests are invited to tour the A. C. Wickman Company, 1425 Queensway, New Toronto, starting at 8 p.m.

Recently Published Reports

The European Convention of Chemical Engineering 1958, Frankfurt (Main), Germany. Lectures delivered at the second Congress of the European Federation of Chemical Engineering and the ACHEMA Congress have been published in seven volumes. They may be obtained free of charge on application to the DECHEMA, Frankfurt (Main) 7, Postfach.

The thirteen papers presented at the Symposium on "The Organisation of Chemical Engineering Projects", held in London in 1958 as the 17th meeting of the European Federation of Chemical Engineering, are now available in book form for approximately $5.50. Orders should be sent to: The Institution of Chemical Engineers, 16 Belgrave Square, London S.W.1.

The Transactions of the Sixth Congress on Large Dams, held in New York, September 1958, are being published in five volumes, the first two of which are ready now. The complete set will cost approximately $40 and should be ordered from: Mr. J. K. Sexton, vice-chairman CNC/ICOLD, c/o Canadian Electrical Association, Room 320, Tramways Building, 159 Craig Street West, Montreal 1.

The Associations and Corporation

The 41st Annual General Meeting of the Corporation of Professional Engineers of Quebec was held on March 19, in Montreal. The theme, "The Engineer in Public Life", was chosen to encourage a wider participation of Professional Engineers in the political and social life of the country. The special guests of honour were the four members of the Corporation who sit in Parliaments: Messrs. Yvon Tasse, Parliamentary secretary of the Federal Minister of Public Works; Maurice Bourget, of Levis, who held the same position under the liberal administration; C. E. Campeau, member for Montreal-St. Jacques, and F. J. Lafontaine, member for Labelle in the Quebec Legislature.

The Association of Professional Engineers of Ontario in the March issue of its publication *The Professional Engineer* has published the decision against Orenda Engines Ltd. handed down in court, at Toronto, February 11 and 12, 1960.

The dismissal of professional engineers upon the abandonment of contracts at the Avro and Orenda plants, with termination pay of one or two weeks, was considered inadequate by the A.P.E.O. Representations were made to the companies and to the Government, contending that the notice did not recognize the professional status of the engineers and that these specialists in question would be lost to Canada if they were not given reasonable time to relocate themselves. The Plaintiff in the Toronto court case, Gustaw Lazarowicz, was awarded "three months' wages in lieu of notice". Orenda Engines Ltd. is appealing the case.

This Month

April 12-27 —Milan International Trade Fair

April 20-21 —ASME and AIEE Railroad Conference, Pittsburgh, Penn.
Muskeg Research Conference (NRC) Calgary.

April 20 —Composite Design in Steel and Concrete Conference, Case Institute of Technology, Cleveland.

April 25-26 —National Maintenance and Plant Engineering Conference, St. Louis, Mo.

April 25-30 —National Industrial Health Conference, Rochester, N.Y.

April 25-29 —Metals Engineering Conference (ASME, AWS), Los Angeles, Calif.

April 28-29 —Canadian Industrial Trainers' Association Conference, Montreal

Future Meetings

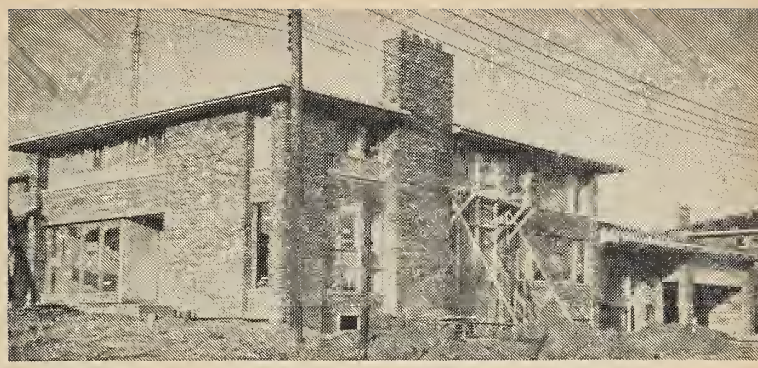
May 2-3 —ISA Electrical Safety Instrumentation Symposium, Wilmington, Del.

May 2-4 —Canadian Highway Safety Council Conference, Vancouver.

May 17-20 —Symposium on Nuclear Reactor Containment Buildings and Pressure Vessels, Glasgow.

(Continued on page 195)

WHEN BUILDERS BUILD Their OWN HOMES



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News of the Branches

New Chairmen: (left to right) J. Benoit, M.E.I.C., Montreal; L. C. Johnson, M.E.I.C., Vancouver Island; H. A. Marshall, M.E.I.C., Halifax; A. M. Toye, M.E.I.C., Toronto.

Assumption University

William Pulleyblank, S.E.I.C.
Correspondent

C. T. Carson, M.E.I.C., production manager of Hiram Walker & Sons Ltd., Walkerville, Ont., addressed the entire student engineering group on March 11. Discussing employment interviews and placement, Mr. Carson outlined what the employment manager looks for in the interviewee and what industry demands of engineers once they are employed. This was of particular value to Assumption students, since next year the first graduates in engineering will be seeking employment.

Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

The Bersimis II Power Project was the subject of a talk by Mr. Clement Forest, assistant chief engineer, Quebec Hydro-Electric Commission, on March 3. Mr. Forest summarised the current position of hydro-electric development in the Province of Quebec, Canada's leading province in hydro power resources. He observed that as further developments take place the cost of generated power will go down until it is below that of Norway, the country with the lowest cost hydro power today.

Mr. Forest described in detail the engineering, construction and administration of the Bersimis II development and accompanied his talk with slides and colour films.

Belleville

Wilburt L. Canniff, JR.E.I.C.
Correspondent

F. Rolf Morral, coordinator of cobalt research center, Battelle Institute, Columbus, Ohio, spoke on the transformation of cobalt and nickel-cobalt at the March 7 meeting. Mr. Morral indicated that the uses of cobalt range from metal alloys to biochemicals. It is vital to alloys which must be heat resistant, corrosion resistant and wear resistant — the sort which are used in turbines and have an expected life span of from a few minutes in a missile to 100,000 hours in a steam turbine. A new use for cobalt, he pointed out, is the addition of 0.5% to the gold plating bath for printed circuits.

University of B.C.

Bud Meckling, S.E.I.C.
Correspondent

This year's membership drive ended with 214 new members. The E.I.C. Professional Development Program is going well. Two field trips and a Spring dance will conclude the student activities for this year.

Brockville

D. B. Ashenden, JR.E.I.C.
Correspondent

Mr. G. van Beck, director of Courtaulds (Canada) Ltd., Cornwall, spoke to members on February 1 on the subject of engineers and accounting methods. He defined the engineer as "someone who can design, build, or repair inanimate things properly at a lower cost than those not so trained," and went on to say that this definition applies particularly to engineers in private industry where the final result is measured by the profits on the balance sheet.

Calgary

Herbert Bailey, M.E.I.C.
Correspondent

Mr. J. Stevenson, of J. Stevenson & Associates, speaker at the February 1 meeting, stated that about 250 Institute members from Alberta are engaged in building construction. What is more, these engineers may be responsible for 80% of the design for a complex industrial building. More often, however, they would handle about 40% of the design under the coordinating hand of an architect. As and if the gulf between architecture and engineering widens in modern building, it is our responsibility, stated the speaker, to pay some heed to it.

Cape Breton

Lloyd R. Boutilier, M.E.I.C.
Correspondent

Mr. R. A. Blackwell, manager of the iron and steel division of Hagan Chemicals & Controls Ltd., Pittsburgh, Penn., gave a talk on application of meters and controls to steel plant processes, February 8. He discussed how his company's controls were adapted to combustion and boiler systems, their use in U.S. industry and the application of computers to process controls.

The 1960 officers of the Cape Breton Branch include: H. M. Aspinall, chairman; R. A. Bradley, vice-chairman; H. C. Maitland, treasurer; J. Lafflin, R. Bezanson, P. R. Terry, J. S. Stevens, G. Oulton, and C. A. Campbell, executive; L. R. Boutilier, secretary.

Carleton University

Thomas A. West
Correspondent

W. R. N. Blair, head of the personnel selection service for the Canadian Army,

Ottawa, spoke to students February 2 on human factors in engineering. Specifications for machine design and control panels, according to Mr. Blair, represent one area where human psychology is taken into consideration.

Central B.C.

A. F. Joplin, M.E.I.C.
Correspondent

President J. J. Hanna met members of the Central B.C. Branch and their wives at a well-attended meeting in the Aquatic Club, Kelowna, B.C., March 9. After the Smorgasbord supper, Mr. E. C. Luke from headquarters, who accompanied Mr. Hanna, spoke on the organization of the Institute and the arrangements for administration. Mr. R. C. Wannop, M.E.I.C., outlined Mr. Hanna's career in the Institute, after which the president gave a State of the Union message on confederation, membership and services.

Mr. Hanna went on to describe three generations of engineers: those who were born prior to the turn of the century and carried a heavy load through the depression years, desiring to carry on the work of comrades lost in the War as well as their own work; a second group, born between 1900-25, involved in the depression and World War II, the present leaders in the profession; and the last, who have little or no knowledge of the depression and were too young to fight in the War. They have grown up in a period of easy credit and a booming economy. They may not always be in sympathy with their seniors.

The president's review of Canadian economy presented a somewhat pessimistic view of the present but suggested that it can be assumed that from now on the outlook is for a long period of stable, if somewhat unspectacular, development.

President Hanna Meets Ecole Polytechnique Students: (left to right) Pierre Lambert, vice-president of the Students' Society; Professor Julien Dubuc, JR.E.I.C., faculty representative; Jules Belanger, president of the Students' Society; Dean Henri Gaudfroy; E.I.C. President J. J. Hanna; Mr. J. M. Boissonneault, secretary-treasurer of the Montreal Branch; and Mr. J. Benoit, chairman, Montreal Branch.

Chalk River

W. O. Findlay, M.E.I.C.
Correspondent

Mr. R. Blackburn, Jr.E.I.C., Mr. J. C. Kingston, M.E.I.C., and Mr. B. Holden were the speakers at the February 17 meeting held in the Staff Hotel dining room, Deep River. Mr. Blackburn spoke on car rallies; Mr. Kingston, on tagging procedures at NPD2; and Mr. Holden, on hospital administration.

Estevan Section (of the Saskatchewan Branch)

On January 19 the Estevan Section of the Saskatchewan Branch of the Institute was officially formed. At this organisational meeting A. Guthrie was elected chairman; J. S. Hunt, vice-chairman; and G. R. Ursenbach, secretary-treasurer. The Saskatchewan Branch endorsed the formation of this new branch at its meeting on January 30, in Regina.

Fredericton

John Burrows, JR.E.I.C.
Correspondent

Mr. Tom Bell, transmission line design engineer with the New Brunswick Electric Power Commission, spoke at the February 22 meeting on current trends in transmission line design.

Hamilton

C. A. McCurdy, JR.E.I.C.
Correspondent

Mr. R. F. Legget, M.E.I.C., director of the division of building research at NRC, discussed ways in which the National Research Council can assist engineers, at the March 17 meeting. He stressed that NRC is neither a branch of the civil service nor a Crown Corporation but a research organization reporting directly to a committee of the Privy Council.

He described the five main services of NBC as: their scientific and technical library, the technical information service, grants for research and scholarship, associate committees such as the Commitee on Soil Mechanics, and assistance by direct contact to engineers and others seeking aid on specific problems.

Kitchener

A. R. LeFeuvre, M.E.I.C.
Correspondent

Professor C. G. E. Downing, head of the engineering science department at Ontario Agricultural College, spoke on engineering applications in agriculture at the February 25 meeting. He traced the developments of tractor power on the farm, outlining the new Allis-Chalmers energy cell tractor; the importance of hydrology; new development in farm structures and harvesting machinery.

This was Student Night and engineering students from Ontario Agricultural College and the University of Waterloo were invited.

Kootenay

Ian Waterlow, M.E.I.C.
Correspondent

Mr. A. Smail, project engineer with the Vancouver Pile Company, spoke on aspects of substructure of New Trail Bridge at the February 18 meeting. This new road bridge will span the Columbia River one mile upstream of the present bridge. It is of revolutionary design to meet the problem of intense scouring by the swift flowing river. The three bridge piers will rest on a concrete cap built at low water level, and supported by concrete piles between which the water can flow.

The new executive of the Kootenay Branch includes: L. S. Piper, chairman; C. G. Rugers, vice-chairman; I. Waterlow, secretary; and G. W. Downie, treasurer.

Executive of the Border Cities E.I.C. Wives' Auxiliary (Windsor): (left to right) Mrs. G. G. Henderson, 2nd vice-president; Mrs. H. J. Chapman, president; and Mrs. J. W. Brison, 1st vice-president.

Lakehead

P. W. Pinn, M.E.I.C.
Correspondent

Mr. Dwight S. Simmons, president of the Association of Professional Engineers of Ontario, addressed a joint meeting of the Lakehead Branch of the Institute and The Association of Professional Engineers on February 26. He discussed a number of Association affairs, among them the recent action by the Ontario Hydro Professional Engineers to have the Labor Act amended; the laying-off of engineers with insufficient severance pay when the A. V. Roe and Orenda contracts were severed; and the work of various committees of the Association.

Col. Medland, executive director of APEO also addressed the meeting on APEO organization.

Lower St. Lawrence

Gerard Fournier, M.E.I.C.
Correspondent

"The Engineer Day" was held February 18, beginning with a television interview in which L. P. Dancose, Georges Santerre, Francois Dore, Guy Thibeaut and Maurice Gagnon participated, answering questions about E.I.C., the Corporation, and the future demand for engineers. In the evening a group went to meet the students of the classical college and technical school at Matane and discussed the various aspects of an engineering career. In the group were: F. Dore, presenting the members; L. P. Dancose, discussing "the engineer"; Jean Menard, "the social responsibility"; Georges Santerre, "the required qualifications"; Paul Begin, "the engineer in industry"; Carol Moisan, "my experience". Gerard Fournier acted as chairman and moderator.

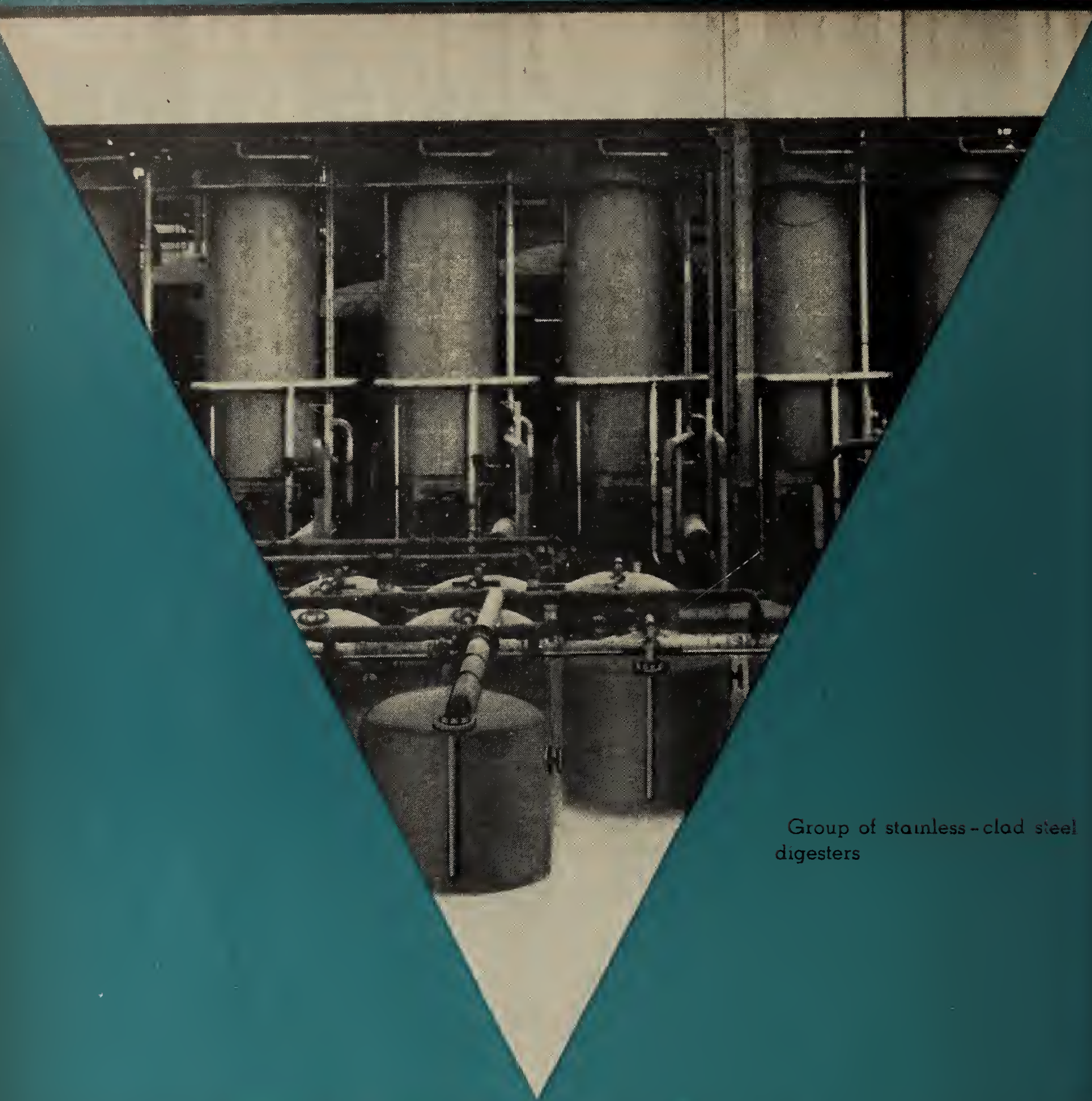
On February 19 the same men went to the Seminary, the secondary school and technical school at Rimouski. Andre Leroux explained the activities of the engineer on a specific job.

February 20 branch members made an industrial visit to the new Quebec Telephone Company installation.

Montreal

G. M. Boissonneault, M.E.I.C.
Correspondent

On February 19, the Montreal Branch was honoured by a visit from President Hanna and the Branch Annual Dinner-Dance was held. The president addressed the students of Ecole Polytechnique in the morning and took advantage of the



Group of stainless-clad steel digesters

occasion to present an E.I.C. Canada Prize for 1959 to Claude Racine, S.E.I.C. That evening, at the banquet, he presented a second E.I.C. Canada Prize for 1959 to McGill student, Edward Higgins, S.E.I.C.

Some 17 members of the branch executive battered their way through drifting snows to attend the luncheon for the president. Guests of honour on this occasion were President J. J. Hanna; Mayor Sarto Fournier and Mrs. Fournier; Mr. J. Benoit, chairman of the Montreal Branch, and Mrs. Benoit; Mr. Garnet T. Page, general secretary of the Institute, and Mrs. Page; Mr. R. A. Phillips, past chairman of the branch, and Mrs. Phillips; Mr. F. L. Lawton, vice-president of the Institute, and Mrs. Lawton; Mr. Racey, representing the Corporation of Professional Engineers of Quebec, and Mrs. Racey; Dr. Henri Gaudefroy, dean of Ecole Polytechnique, and Mrs. Gaudefroy; Professor de Stein, representing the dean of engineering, McGill University, and Mrs. de Stein; Mr. R. B. Walker, chairman of the Junior Section of the Montreal Branch, and Mrs. Walker.

Newfoundland

Mr. J. Hoogstraten, president of Nova Scotia Technical College, gave his views on education for engineers and technicians at the March 3 meeting. He stressed the increasingly scientific approach to and content of engineering education. More pure science and mathematics are being included in the engineering curriculum, he stated. This trend can be traced in the qualifications of teachers in engineering schools. Whereas in the comparatively recent past schools looked for broad professional qualifications in their faculty, they now choose young instructors who have advanced degrees and are interested in research rather than outside professional activity.

Discussing the technician, Mr. Hoogstraten pointed out the need for a definition of his position. With the greater scientific content of engineering courses, it would be advantageous to have courses of rather narrower technical limits to train technicians.

Niagara Peninsula

Edward C. Little, M.E.I.C.
Correspondent

F. J. Travers, senior project engineer for H. G. Aerosoles Ltd., was to be the speaker at the February 25 meeting and had planned to discuss the Chute des Passes power development. However, due to the heaviest snowstorm of the winter, the meeting was cancelled at the last moment.

Dr. J. W. Hodgins, dean of engineering at McMaster University, Mr. G. O. Loach, president of Electro Metallurgical Company, Welland, and Mr. C. Norman Simpson, director and general manager of technical services for H. G. Acres & Company Ltd., Niagara Falls, were the speakers at the meeting on March 17.

Dr. Hodgins spoke on "What the future holds for the young engineer in teaching and research"; Mr. Loach, on "The function of engineering in manufacturing"; and Mr. Simpson on the qualities a young engineer should have. High school pupils and teachers were invited to this meeting and the total attendance was approximately 75.

Northern Nova Scotia

Robert S. Morrow, M.E.I.C.
Correspondent

On February 25 members of the Northern Nova Scotia Branch, with their wives and friends, held a "Ladies' Night" dinner and dance in the ballroom of the Norfolk Hotel in New Glasgow. There was Scottish dancing and music during the meal, and following that, Dr. Nordeau Goodman showed kodachromes taken in different parts of the world. An evening of dancing followed. Seventy-eight members and guests were present.

Ontario Agricultural College

L. L. Gordon, S.E.I.C.
Correspondent

On February 11 engineering students attended a joint meeting of the Kitchener-Waterloo Branch of the Canadian Welding Society at which Mr. W. A. Wright, metallurgical engineer with the Linde Company, spoke on "New Developments in Sigma Welding on Light Gauge Materials".

Ottawa

H. P. Ristow, JR.E.I.C.
Correspondent

Mr. Alex MacRae of Alex E. MacRae & Company, patent agents, Ottawa, gave a talk on "Social Engineering" at the February 18 meeting. The engineer should act to interpret scientific truths to society in words which people understand, Mr. MacRae stated.

On March 3, Dr. Guy B. Ballard, vice-president of NRC, spoke on his recent three-week tour in Russia. He reported that scientists live as well or better than their equivalents here and that workers live probably as well as their equivalents in other parts of Europe outside the highly developed urban centers.

Saint John

Harley K. Larsen, JR.E.I.C.
Correspondent

A dinner meeting was held at the Admiral Beatty Hotel on March 9. Mr. Lee Henning, president of Irving Refining Ltd., gave a general outline of the operation of the new $50,000,000 Irving refinery just completed in East Saint John. When the first shipment of crude oil, due at the company's dock March 19, arrived from Iran, the refinery was to go on stream.

Sarnia

Paul Donato, M.E.I.C.
Correspondent

Dr. Harold Waldron, head of the aeromechanics section of CARDE, discussed some aspects of missiles research in Canada at the February 23 meeting. An important phase of CARDE research, said D. Waldron, is the development of equipment to discover the approach of enemy intercontinental ballistic missiles.

University of Saskatchewan

K. R. McCullagh, S.E.I.C.
Correspondent

The annual Students' Papers Presentation, sponsored by the student section of E.I.C., was held in the campus Memorial Union Building on February 18. Four papers were presented by senior students and over 50 student and senior branch members were in attendance. First prize of $25 was awarded to Mr. E. C. Turgeon, in engineering physics, for his paper, "Experiments by Land, in Two Colour Photography"; second prize, to Mr. Z. R. Patzernuik, for "Vision and Illumination". Mr. B. A. Lundeen presented a paper on "The La Ronge — Uranium City Highway" and Mr. W. C. Paynter presented one on "Considerations for Secondary Recovery of Oil."

Sudbury

Archie B. Platt, JR.E.I.C.
Correspondent

On February 11, members heard Mr. Robert Currier, manager of product planning with the Ford Motor Company of Canada, Ltd., Toronto, speak on the planning of an automobile and related engineering functions. He placed emphasis on a three-year planning stage, in the course of which for any one model numerous details are worked out between engineering, styling and production. The success of any model year, he pointed out, depends upon the complete dove-tailing of various departments so that the overall plan meets the quality and cost objectives in a competitive market.

John Redfern, Jr.E.I.C., technical engineer with the Canada Cement Company, Ottawa, discussed some aspects of concrete design and application at the March 10 meeting. Seven first-year students from Laurentian University of Sudbury were among the 35 present. The speaker illustrated his talk with two films, "From Mountains to Microns" and "Concrete 58".

Vancouver

C. H. White, M.E.I.C.
Correspondent

Mr. Peter Jorgenson, chief engineer in the Vancouver office of Christiani & Nielsen of Canada Ltd., introduced the film "The Deas Island Tunnel", produced by the B.C. government, which was shown to members on February 16.

On March 15, Mr. Alan A. Kay, M.E.I.C., of G. S. Eldridge Ltd., spoke to members on "Quality Control and Construction". Ninety-five members of the Structural Steel Section attended this meeting.

Victoria

W. Tivy, M.E.I.C.
Correspondent

Dr. David M. Myers, dean of the faculty of applied science at the University of British Columbia, discussed engineering opportunities in Australia at the February 24 meeting. He stated that in Australia, and probably in Canada, five technicians were needed for every engineer, but facilities were not available to train them.

Winnipeg

Peter M. Abel, JR.E.I.C.
Correspondent

Robert F. Legget, director of the Division of Building Research at NRC, spoke to members on February 18, discussing building research in Winnipeg and Western Canada. He discussed various aspects of construction design, foundation problems and insulation which are being experimented with in the prairie region, and gave a full account of heat control houses located on permafrost for studies of insulation. Following the address, Mr. Ken Smith showed a film entitled "Setting Fires for Science", which deals with the Department of Building Research's study of burning brick and frame houses under controlled conditions.

Civil Section
Arnold Bookbinder,
Correspondent

Mr. James O. Granum, deputy chief engineer, highways division, Automotive Safety Foundation, Washington, D.C., gave a talk on "Attacking Highway Problems in the U.S.A." on February 11.

The new executive of the Civil Section includes: I. B. Henderson, chairman; T. A. Crosier, past chairman; L. H. Macdonald, vice-chairman; F. G. Denson, secretary; D. Murray, papers chairman; J. P. Scaitex and G. R. Reshaur, executive members.

Engineers' Wives Associations

Belleville: Although there is no official organization in Belleville, Mrs. W. C. Benger, whose husband is chairman of the Belleville Branch, and the wives of the members of the executive invited wives of the branch members to a dessert party on March 23, at Mrs. Benger's home.

Border Cities: The 1960 executive is as follows: president, Mrs. H. J. Chapman; 1st vice-president, Mrs. J. W. Brison; 2nd vice-president, Mrs. G. G. Henderson; recording secretary, Mrs. H. Bily; corresponding secretary, Mrs. E. T. Rivington; treasurer, Mrs. A. McCaw; publicity convenor, Mrs. D. Servage; groups convenor, Mrs. D. Osmun; councillors, Mrs. C. M. Armstrong, Mrs. J. Reid, and Mrs. E. Dykeman.

Corner Brook: The first meeting of this new group was held at the home of Mrs. Thomas T. Rose on November 9, 1959, and it was decided that the group would meet every third Monday evening.

Kitchener: A constitution was adopted at the January meeting and the group was officially given the name "The Engineering Institute of Canada K.W.G.P. Wives Association" incorporating Kitchener, Waterloo, Galt, Guelph and Preston. Meetings are to be held in each city in turn.

Moncton: Seven new members were welcomed at a bridge party held at the home of Mrs. M. F. K. Leighton in February.

Niagara Peninsula: A luncheon was held at the Niagara Falls Club on March 5. The annual membership tea will be on April 28, again at the Niagara Falls Club.

Ottawa: The Annual Spring Luncheon will be held on May 4. The location is not yet settled.

Peterborough: The Auxiliary is planning to hold their first supper dance on April 12, with a Gay Nineties theme. Port Hope Branch members and wives will be invited.

Port Hope: A dinner dance will be held April 29.

Toronto: A Spring Luncheon was held March 1 at the Granite Club, with 100 members present. Mrs. C. P. Sturdee is the new president and Mrs. A. C. Davidson is vice-president.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

• DISCUSSION

(Continued from page 143)

that only turnkey jobs could be expected to be successful. It is also only logical, because after all it is much easier for someone in a remote area to buy a fully finished project, instead of buying the brain work in advance of the actual project. It follows that while the beginning should be done by the consulting engineer, the execution of the project in nearly every instance would be done on a consortium basis. This has been very well described by Mr. Frigon and there is very little I could add to it in these remarks. In my opinion, I would say that it should include the consulting engineer, the manufacturer, or contractor, and possibly even the financing agency as well.

(c) The help of our trade commissioners is absolutely essential. The more conversant one becomes with the work they are doing, the more one realizes and appreciates the wonderful job being undertaken by them for the benefit of everyone concerned. The interest shown by Mr. Frigon in this field is well exemplified by the thoroughness and manner in which he has presented this paper. He is to be congratulated.

Discussion by Jasper H. Ings, M.E.I.C.

In opening my discussion on this excellent paper I would first of all like to pay tribute to our Canadian Foreign Trade Service and particularly to the various Trade Commissioners or Commercial Secretaries whom I have met in my travels. Without exception, all of the people whom I have encountered in the Foreign Trade Service have been extremely cooperative and very helpful.

I am sure that all of you will realize that when one disembarks from a plane in some foreign country where language, customs and even methods of thinking differ, it is a tremendous boon to the travelling individual to find someone who is ready, willing and able to give as much help as possible, to offer advice and to make appointments on one's behalf. Occasionally even to act as an interpreter at meetings. Quite frankly, I cannot speak too highly of our Canadian personnel who perform these services and I can assure you that our representatives stand far above those of most other countries in this regard. In my experience Trade Commissioners regard it as their first duty to help the Canadian abroad.

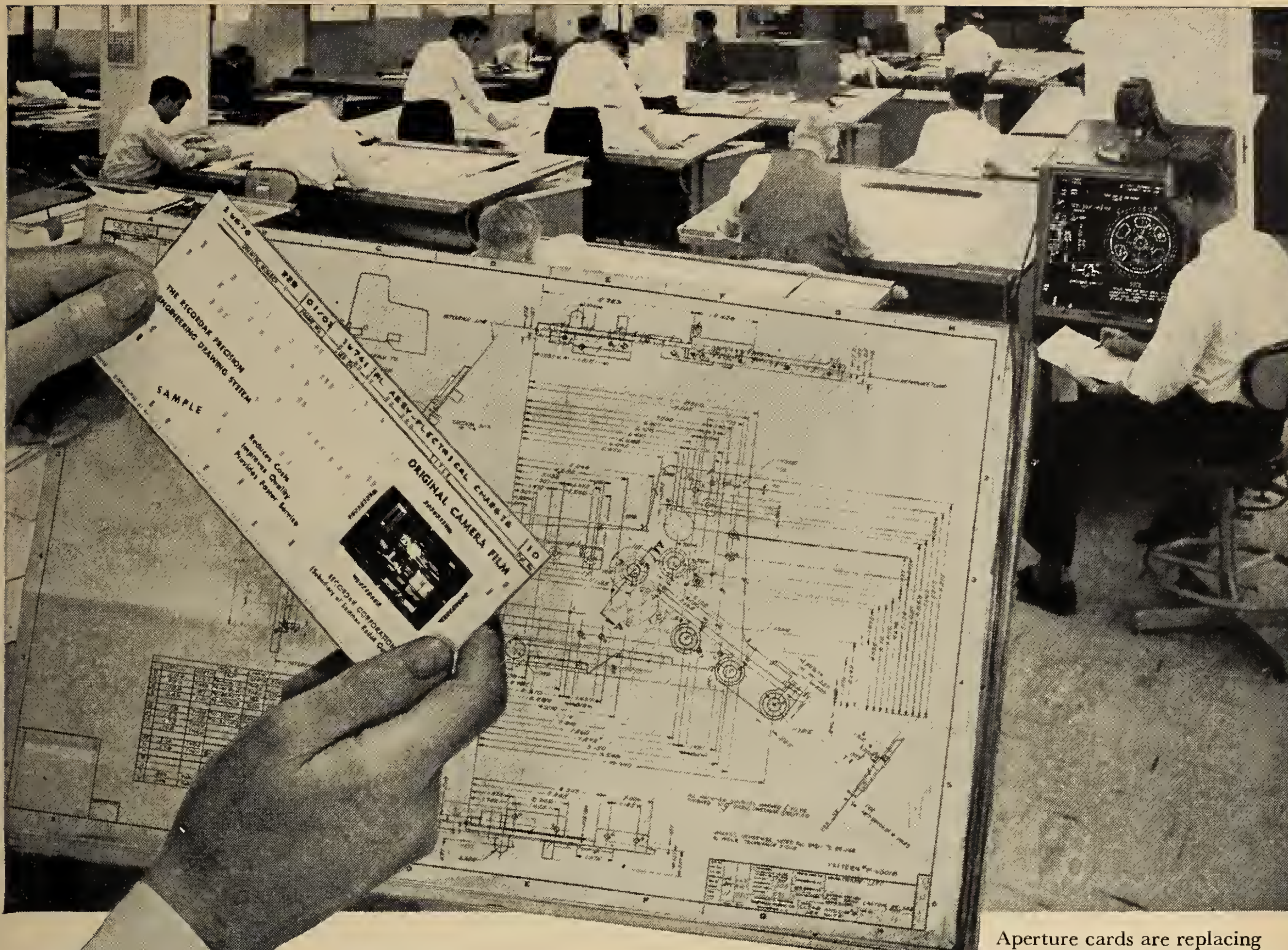
Something which, possibly, is not set out in Mr. Frigon's paper but which is of interest to the consultant are the gains to be obtained from foreign work and in this regard I am not thinking entirely of financial gains. Apart from one's normal profits foreign projects offer three definte attractions to the company participating in work abroad:

(a) The filling out of the home production work curve is a gain which frequently leads to stability of staff.

(b) Overseas work gives a great broadening of both technical and personal experience to the individuals concerned. One sees foreign methods of design and construction radically different from what one may be used to at home but achieving the same results. This sort of thing is in itself a great means of shaking the individual out of the rut.

(c) When participating in foreign work one often has to deal with governments and government departments, both our own and those of the clients overseas. This has a salutary influence on the individual in that he learns to develop patience as necessarily government methods by their very nature differ from those encountered when dealing with private enterprise.

To obtain consulting work abroad there is no better method than the personal contact. It is true that this calls for what are sometimes strenuous trips, but there is no question whatsoever that the personal call on individuals overseas carries the most weight and arouses interest to a far greater extent. It is one thing to read in the technical press that an individual or a consulting company has accomplished a certain job, but it is another thing entirely when a representative from that company walks in the door prepared to offer their services to the development of the country concerned.



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Apart from making oneself known in any given country, sooner or later one sees the advisability, if not the necessity, of establishing a local agent or liaison officer. Such a person, particularly when it comes to working out a definite contract, can be of tremendous assistance due to his knowledge of local laws, customs, finances, taxes, legal pitfalls and so on. However, it is imperative that such a person be chosen carefully and there are three criteria which must be met:

(a) The agent must have personal stature in his own country.

(b) He must show an above-normal competence in his own work.

(c) Most important of all, his integrity and good character must be unquestioned.

The paper gives some comments on consortia formed to undertake overseas work. I would like to point out, however, that sometimes such groupings are not always the answer. From the consulting point of view, one can quite easily get into a difficult ethical position which could give the appearance of trying to work both sides of the street. In addition, in some areas there are definite legal bars which prevent a consultant from associating himself in any way with a contractor on the work to be undertaken. I may say that I have run into this particular bar in Ceylon. Nevertheless there are times and areas where consortia may be the answer and such groupings are more favourably regarded in South America. The future may see more and more of such joint ventures in Central America and South America.

Sometimes, however, there is another type of consortium which may work. That is a grouping of consultants in which each may undertake a given phase or specialty of an investigation or project. Here again though, care must be taken in the selection of one's partners in such a venture.

It is not intended in this discussion to enter into the detailed aspects of the financing of overseas work. I would like, however, to point out that in some respects Canadians are operating at a disadvantage compared to the nationals of other countries. I have heard of individuals abroad quite frankly saying that they would be coming to, say, Washington to go shopping for credits, aid and loans. As we are all aware the United States has been extremely generous in helping other countries and particularly the underdeveloped countries. This has resulted in building up a multiplicity of banking and lending institutions, helping agencies and so on. Canada, on the other hand, seems to have just one agency to assist the underdeveloped countries and that is our excellent Colombo Plan Administration, which, as you all know, is a joint Commonwealth venture. The Colombo Plan is operated efficiently and very helpfully and I can say from my own experience is generally appreciated abroad. Nevertheless, it is only one agency, and one which must operate with limited funds. Governments abroad, of course, know of all the various loaning and helping methods set up in other countries and quite naturally wish to take full advantage. After all, why work with one's own money under difficult foreign exchange conditions if somebody else will take that part of the burden off your shoulders? The result of this, therefore, to the individual Canadian is that he is at a distinct disadvantage in that his American, French, German or Italian competitor can mobilize loans, credits or even subsidies which may spread the financial load of the client over a period of some years. Offsetting this, it is sometimes possible for a Canadian firm to get in under some other country's loan or aid program through association in a joint venture with an affiliated company.

GEOLOGICAL FEATURES AND FOUNDATION TREATMENT AT THE BEECHWOOD DEVELOPMENT

I. D. MacKenzie, M.E.I.C., *Geologist*

E L. Brown, M.E.I.C., *Field Engineer, The Shawinigan Engineering Company Limited, Montreal, Que.*

The Engineering Journal, 1959, December, p. 54.

Discussion by Robert March, M.E.I.C.

The writers are to be complimented on producing such a complete coverage of the geological conditions at the Beechwood site and the work done to consolidate rock which otherwise was unsuitable for superimposing a dam and power house structure. At the time Beechwood was constructed Mr. Brown was on the Power Commission's field staff and was assigned the supervision of subterranean drilling and pressure grouting and the carrying out of directions from Mr. MacKenzie, geologist at Shawinigan Engineering's head office. Both men were accordingly well equipped to handle that phase of the Development which they have chosen as a subject.

Within the limits of that subject I find nothing to add and nothing to question. It may be of interest however to add a few remarks on some of the ways in which construction was affected by foundation conditions which were not apparent or suspected until uncovered.

One effect common to all discoveries of unfavourable conditions was the loss of time while decisions were made and plans were changed. The other common effect, of course, is the increase in cost to keep the structure sound against adverse conditions. You do not decide overnight how to proceed when you find a fault in the foundation rock which may increase costs by a quarter of a million dollars.

From my experience at Beechwood and at other river construction sites I would strongly urge engineers to insist with their clients on the importance of ascertaining information as completely as possible on the condition and quality of foundation rock. At Beechwood the information given to bidders for tendering looked to be thoroughly complete but it developed that there was all the difference in the world in the half of the river bed west of the fault and the half east of the fault.

The massive formation west of the fault had very few joints and the surface in many places was almost polished by sand and gravel carried by the stream. Concrete was poured on these surfaces without excavation for most of the piers and rollways. Toward the west bank an old channel worn about 30 feet deep in the rock and much wider than indicated by borings and filled with gravel was encountered. A test pit in the gravel revealed that water flowed freely through it but carried no silt. It was considered necessary to impregnate the gravel in this old channel where it crossed under the upstream cofferdam with a thick cement grout. Between 2000 and 3000 extra yards of concrete were required for the dam in crossing this old channel.

Heavy excavation of the vertically jointed and badly shattered shale in the power house area was accomplished mostly by horizontally drilled lifters at successively lower levels. The last lift was always shallow — about 5 ft. and shot much lighter. In spite of all precautions it was very difficult to scale and cleanup either vertical or horizontal surfaces suitable for pouring concrete. Light excavation as under the intake structure had to be done without using explosives. Bulldozers, compressed air jets and air tools were used. Overbreak under the intake was heavy and an extra concrete mat was placed on the rock and carried as a face wall down the step to draftube floor level. By drilling through the mat and face wall a low pressure grouting job was done to consolidate and seal the rock contiguous to the structure.

The artesian water encountered in a number of drill holes made tight grouting very nearly impossible. It was regretted toward the end of the job that an artesian well was not developed as a drinking water supply for power house use.

It has been said of the Saint John River that it is only consistent in the regularity of its inconsistencies. We found this to be as true of the river bed and the underlying rock as it is of river flows. This is no doubt true of many other streams.

I again repeat that preliminary boring information should be as complete as possible. Hind sight at these jobs should teach us that the drill cores should be carefully analyzed and studied by both the engineers and the contractors.

Discussion by Prof. A. L. McAllister

The very detailed treatment of the grouting procedure and location and spacing of grout holes and curtains should provide extremely valuable information to engineers engaged in similar projects elsewhere.

A zone of slates and blocky argillites such as is found at the Beechwood dam site, will almost invariably be cut by a number of small slip zones or minor faults and be characterized by seepage along these breaks as well as along cleavage planes and fracture zones. In any site underlain by such rocks a duplication of Beechwood conditions can be anticipated. The experience gained at Beechwood and so well described in this paper will be especially appreciated in New Brunswick, where a number of possible sites underlain by similar rock have been partially investigated.

In a slate environment, cut by a number of minor slips as at Beechwood, lost core and blocky zones are common problems in drilling. In areas where cleavage parallels the core recovery is particularly low. It is thus generally impossible to recognize significant fault zones from results from a single hole. It is particularly important that all drill results be immediately recorded on sections across the site so that correlation can be made from hole to hole. This is the only way that a comprehensive geological picture can be attained, and the additional cost over and above drilling is negligible. From a geologist's point of view one or two such geological sections across the Beechwood site would have done much to clarify the geological picture described in this paper.

Also from a geological point of view I would like to comment on the enclosed map showing the generalized geology of New Brunswick and Northern Maine. On this map the area is divided into areas underlain by rocks of different ages, Carboniferous, Devonian, mainly Silurian and mainly Precambrian. Without criticizing the validity of the generalization I would suggest that such a division, based solely on rock ages, conveys little information of significance in dam construction. For example, the area of Beechwood and most of the drainage basin north of it is described simply as being underlain by rocks of Silurian age. A better approach would be to describe the area as underlain by slates, shales and argillites, a fact which is of significance in future upstream construction and which has directly controlled the quality of the local gravel supply. Other areas southeast of Beechwood described as Devonian could also much better be simply described as being underlain by granite.

Discussion by
Prof. H. W. McFarlane, M.E.I.C.

Mr. MacKenzie and Mr. Brown are to be congratulated on their full coverage of the subject. It is interesting to note some of the effects the grouting program had on other aspects of the construction.

Since it was impossible to determine in advance the amount of grouting required and therefore the amount of time required for grouting, the time scheduling of the other operations became extremely difficult.

For instance, as late as the middle of May 1956 it was hoped that construction of the earth dam section could begin about the first of June. This would have allowed the earth compaction to take place during the longer days of June and July. The earth work however could not begin until the foundation was properly treated, and could not proceed far until the retaining wall was erected between the earth dam and the intake section. Construction of the retaining wall was in turn delayed by treatment of the foundation rock of the intake section where the situation had been aggravated by discovery of the fault described in the paper.

The starting date on the earth fill was delayed again and again until the first fill finally went in on August 6. The moisture content of the core material was excessively high and although a few days of dry weather would reduce the moisture content to acceptable values the "few days of dry weather" turned out to be rare. Rains that summer were not heavy but they were frequent. The days were getting shorter and the sun producing less drying power as time went on. It became more and more difficult to dry the fill by aeration. August and September passed, half of October passed. The fill was nowhere near complete and was proceeding very slowly.

Unless the earth dam reached a sufficiently high elevation before winter set in, work on the complete dam would be held up until after the spring freshet.

Many possibilities were discussed and finally it was decided to dry the impervious fill in an asphalt aggregate dryer. Once this artificial drying process was set up the fill progressed steadily. The impervious core reached the necessary elevation on November 21 and the other aspects of the job were able to go ahead on schedule.

The following spring the earth fill was brought up to design elevation quickly, and without difficulty.

Although other factors contributed, this chain of events was really started by the delay caused by the unpredictable amount of foundation grouting required.

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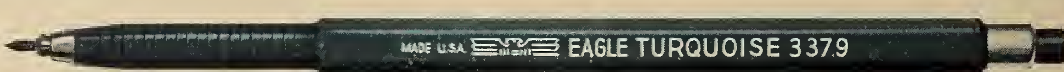

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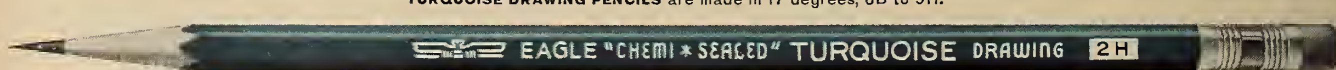

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Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*PRINCIPLES OF PAVEMENT DESIGN

The basic principles that apply to the design of airfield and highway pavements are presented, and data is provided for establishing the design criteria to fit the many conditions that may be encountered in practice. Both theoretical and practical aspects of the field are covered in sections dealing with the properties of pavement components, design tests, the design of flexible and rigid pavements and pavement evaluation and strengthening. Examples illustrate the various design methods described. (E. J. Yoder. New York, Wiley, 1959. 569 p.,

THE MANUFACTURE OF IRON AND STEEL: VOL. 2. STEEL PRODUCTION.

In this revised edition, new material has been added to bring the book up-to-date, and a chapter is included on the physical chemistry and thermodynamics of steelmaking. The volume surveys the basic principles underlying the modern processes of steel production, and the plant and equipment employed. Some of the topics covered include: the Bessemer process; open-hearth; acid open hearth; electric furnaces; special steels. (G. R. Bashforth. Toronto, Ryerson, 1959. 390 p., $8.00)

A SHORT HISTORY OF SCIENTIFIC IDEAS TO 1900.

The author's intention in writing this volume is to give some idea of how science came to occupy its distinctive position in modern life. He places basic scientific ideas in the framework of world history, and indicates particularly some of the less well-known factors, such as the influence of the Arabic-speaking world. The author covers his subject from the early days of Mesopotamia to 1900.

Mr. Singer is well-known as an editor of the five-volume "History of Technology," issued by the same publisher. (Charles Singer. Toronto, Oxford, 1959. 525 p.)

*ELECTRONIC ENGINEER'S REFERENCE BOOK.

This handbook, written from the point of view of British practice, covers the following areas: fundamental concepts; radiations, including infra-red and ultra-violet sources with their industrial and medical applications; electron tubes, including design of tubes and measurement by electronic instruments; materials, particularly those that are magnetic; vibrations; computers; automation. (Ed. by L. E. C. Hughes. Toronto, Macmillan, 1958. 1311 p., $18.00.)

DIESEL ENGINEERING HANDBOOK, 10th ed.

Now completely re-written, this tenth edition places increased emphasis on basic engineering principles, and the design and construction of present-day engines and their auxiliaries. The twenty-nine chapters cover such topics as fuels, combustion, fuel injection systems and pumps, pistons and rings, air systems, lubrication, speed governors, gas and dual-fuel engines, and engine drives. An appendix includes information on current makes and models and specifications for diesel, dual-fuel and natural gas engines. (K. W. Stinson. Stamford, Diesel Publications, 1959. 383 p., $10.00.)

ENGINEERING MECHANICS

An undergraduate text on engineering mechanics for all engineering students, written in an informal style. The authors have used the vector notation, and in the statics section the concept of a fixed vector. Problems are used to point out the applications of mechanics in a variety of classical and modern technological fields. Their solutions are found by the vector method. (D. F. Gunder and D. A. Stuart. New York, Wiley, 1959. 391 p., $7.75.)

INTRODUCTION TO PROBABILITY AND STATISTICS

An undergraduate text, intended to provide the student with a basic foundation. The first five chapters deal with probability models, and other chapters cover sampling, the presentation of data, testing statistical hypotheses, estimating and testing variability, etc. A final chapter provides a brief introduction to sequential analysis, analysis of variance, regression, and decision theory. References are included for further reading, and review problems, many of which are drawn from the engineering field. (B. W. Lindgren and G. W. McElrath. Galt, Brett-Macmillan, 1959. 277 p., $6.25.)

INDUSTRIAL ACCOUNTING, 2nd. ed.

The emphasis in this book is on learning to use, rather than to do, accounting. The first thirteen chapters provide a firm foundation in basic accounting principles and bookkeeping procedure. The next seven chapters cover the main features of sole proprietorship, partnership and corporation accounting. The final fifteen chapters deal with cost accounting theory and procedure. (S. W.-Specthrie. New York, Prentice-Hall, 1959. 583 p., $10.00.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 A.M. to 5 P.M.; All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

COLLECTIVE BARGAINING AS VIEWED BY UNORGANIZED ENGINEERS AND SCIENTISTS

This is a report of the opinions of 264 non-supervisory engineers and scientists on the subject of collective bargaining for professional employees. It analyses critically the reasons given for and against collective bargaining, and presents some of the ideas put forward on the causes of unionization among engineers and scientists. This is one of a series of reports on management's relations with engineers and scientists. (J. W. Riegel. Ann Arbor, University of Michigan, Bureau of Industrial Relations, 1959. 105 p., $4.00.)

SUCCESSFUL TECHNICAL WRITING

In his first chapter the author cites some of the advantages of writing technical articles, and suggests various markets available to writers. He next enumerates twelve types of technical articles, and the characteristics of each.

Chapter three is concerned with the problem of finding and developing suitable ideas for articles, and subsequent chapters cover actual methods of writing articles, technical papers, reports, manuals and catalogues. Three final chapters are devoted to writing the technical book.

This should be required reading for all engineers. (T. G. Hicks. Toronto, McGraw, 1959. 294 p., $6.35.)

MACHINES A CALCULER ELECTRONIQUES: ARITHMETIQUES ET ANALOGIQUES

One of the few volumes in French on the subject of electronic calculating machines, this commences with an introduction explaining the terms used, and the different types of machines available.

The first section covers analogue computers, and the second, and larger, digital computers. In both sections, information is given on the various types of machines available, the manner in which they work, and their applications. The author has had experience working with computers in the United States. (M. Pelegrin. Paris, Dunod, 1959. 395 p., 4,400 fr.)

LA MACHINE-OUTH, TOM 7 & 8.

The seventh volume of this series on machine tools is concerned with forging. The ten chapters, each by an expert, cover such topics as: creep and heat tests; forgeability of metals and alloys; deformation of metal during welding; heat required for forging; forging machines; stamping and stamping machines.

The eighth volume covers the machining of wood and plastic, the machinery used, methods of work, and finished products. There are also chapters on the application of electronics in the machine shop, and the use of hydraulic and electrical control systems. (Ed. by A. R. Metral. Paris, Dunod, 1959. V. 7, 452 p., 7,400 fr.; V. 8 222 p., 3,900 fr.)

LIANTS ROUTIERS ET ENROBES: MATERIAUX DE PROTECTION-PLATRE-AGGLOMERES-BOIS.

The first section of this volume deals with the so-called "black" binding materials, tar, asphalts, pitches and rubber asphalts. The second section covers hydrocarbonic concretes, and the third, terms used in highway engineering. Other sections deal with plasters; clays; ceramics; glass; waterproofing materials, rubber, paints and varnishes; plastics; and wood. In each case, information is given on the properties and uses of the materials, results of tests performed, specifications etc. (J. Arrambide and M. Duriez. Paris, Dunod, 1959. 553 p., 2,475 fr.

L'ENTREPRISE ET LA STATISTIQUE: TOME 2, STATISTIQUE ET GESTION DE L'ENTREPRISE, 2 ed.

This second, revised edition has been divided into two volumes, the first of which is concerned with statistical techniques and documentation. The second volume considers the practical application of statistics to the management of a business, including control of manufactures; operations research; market research; trade outlook; statistics and accounting. Also considered is the organization of a statistical section in a firm. References for additional reading are given. (R. Dumas. Paris, Dunod, 1959. 252 p., 2,800 fr.)

ELECTRONS, ATOMES, METAUX ET ALLIAGES

Translated from the English, this volume considers the mathematieal developments of wave mechanics, and their application in the structure and properties of metals and alloys. The first two sections of the book consider the nature of the atom, and the nature of metals. The third discusses the nature of alloys, whilst the last section examines the structure of the nucleus. The book is written in the form of a dialogue, mostly questions and answers. (W. Hume-Rothery. Paris, Dunod, 1959. 456 p., 3,900 fr.)

DICTIONNAIRE ANGLAISE-FRANCAIS: ELECTRONIQUE, PHYSIQUE NUCLEAIRE ET SCIENCES CONNEXES

The 24,000 terms in this dictionnary are those encountered by the author in his day-to-day work in the fields of electronics, nuclear physics and related sciences. Any differences between English and American usage have been clearly shown. A French-English volume is in preparation. (G. G. King. Paris, Dunod, 1959. 311 p., 2,600 fr.)

*CALCULATEURS NUMERIQUES, ELEMENTS ET CIRCUITS

A French translation of a 1957 U.S. publication, this basic text for the student or practising engineer emphasizes basic engineering approaches to digital techniques. A wide range of components and circuits of an experimental nature is covered, as well as logical functions and digital storage, basic operations to be performed by a digital computer, and the advantages and disadvantages of various approaches to design. Design concepts are stressed rather than specific details. (R. K. Richards. Paris, Dunod, 1959. 538 p., 6,400 fr.)

CALCUL A LA FLEXION DES COQUES CONIQUES

The authors' firm has been conducting studies for several years on shells. In this volume are published some of the studies on the deformation of conical shells, axisymmetrically loaded. The results are given in tabular form at the end of the volume, and permit the calculation of strains and deformation in "short" or "long" truncated cones. A bibliography of 31 references, more than half of which are in English, is included. (S. Casacci and J. Bosc. Paris, Dunod, 1959. 161 p., 1,800 fr.)

METHODES ET MODELES DE LA RECHERCHE OPERATIONNELLE

Another in a series on business economics, this volume outlines the applications of mathematics in industry in the field of operations research.

The book is divided into two parts, the first of which gives specific instances of its use, with actual case histories. In the second part, chapter by chapter, are given the mathematical methods used, worked examples, algorithms, etc. The topics covered include linear programming, queuing problems, inventory control, and the replacement and maintenance of equipment. Most of the references in the twelve-page bibliography are to U.S. publications. (A. Kaufmann. Paris, Dunod, 1959. 534 p., 6,800 fr.)

METALLURGIE DE LA SOUDURE

Already well-known for his books on welding, the author in this volume considers the metallurgy of welding, which has become of increasing importance as welding is used more and more in construction.

In the first part he deals with the metallurgical aspects of the welding of steels, the processes used, structure of the weld, arc-welding, absorption of gas by welds, cracking and pre-heating.

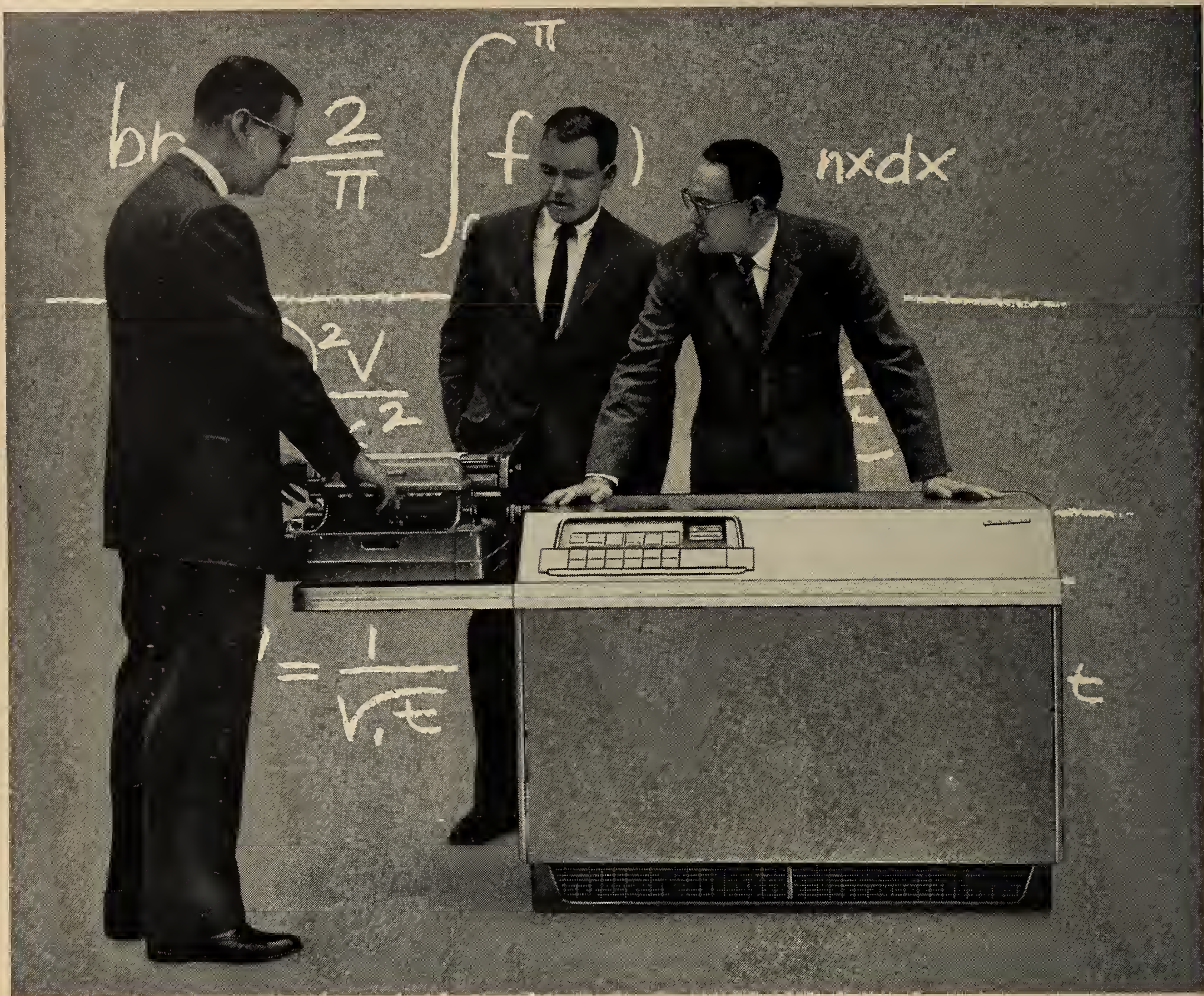
In the second section there is a discussion of the weldability of different types of steel, including carbon, austenite, nickel-chrome, boron and chrome-molybdenum and other semi-refractory steels used in the petroleum industry. (D. Seferian, Paris, Dunod, 1959. 393 p., 5,800 fr.)

LES MACHINES S'EN CHARGERONT

A translation from the English "Let ERMA Do It", this volume presents a brief history of automation, outlining its principles and applications in various fields—accounting, manufacturing, production control, etc. The author gives social and economic reasons for the use of automatic machines, and mentions examples of their use.

The second part of the book gives more details on the different machines and their uses, including ERMA, RESERVISOR, and SAGE. References are given for further reading, but there is un-

(Continued on page 173)



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• LIBRARY NOTES

(Continued from page 167)

fortunately no index. (D. O. Woodbury, Paris, Dunod, 1959. 303 p., 1,480 fr.)

PROCESSUS ALEATOIRES ET SYSTEMES ASSERVIS

A translation of the McGraw-Hill publication "Random processes in automatic control", this volume provides both the practical engineer and the research scientist with the basic theory of random signals and noise, together with techniques used in the analysis and synthesis of linear control systems subjected to random inputs. It considers the basic concepts of probability and random time functions using them to develop analysis and design techniques for linear control systems containing both constant and time-varying components. (J. H. Laning and R. H. Battin. Paris, Dunod, 1959. 442 p., 6,600 fr.)

LES SEMICONDUCTEURS ELECTRONIQUES

An introduction to the physics of rectifiers and transistors, commencing with an explanation of the mechanism of conduction in semiconductors, network imperfections and impurities, and the functions of crystal rectifiers and amplifiers. In the chapters on the physics of semiconductors, the author considers the problem of the hydrogen molecule in quantum mechanics, Fermi statistics applied to the electrons of a crystal, reactions between centres of impurities, and the electrical properties of the surface of solids.

This is a translation from the German edition. (F. Spenke. Paris, Dunod, 1960. 349 p., 5,600 fr.)

TECHNIQUES DES ULTRASONS

The first two chapters of this text discuss the characteristics and measurement of ultrasonic waves, and the nature of cavitation. The next four chapters discuss generation, including piezoelectric and magnetostriction transducers, jet generators and electro-magnetic transducers.

The second half of the volume is concerned with the applications of ultrasonics in engineering, in such processes as precipitation and agglomeration, emulsification and dispersion, metal coating and cleaning. Also considered are their uses in the fields of chemistry, metallurgy, biology and medicine, and in control instruments. (A. E. Crawford. Paris, Dunod, 1959. 456 p., 4,800 fr.)

TRAITE D'EXPERTISE ET D'ESSAIS DES MATERIAUX ET DES CONSTRUCTIONS. METHODES GENERALES D'ESSAI ET DE CONTROLE EN LABORATOIRE: TOME I — MESURES GEOMETRIQUES ET MECANIQUES

The first volume of a new series to be published by the Institut Technique du Batiment et des Travaux Publics, on testing materials and structures. This volume is concerned with general methods of testing and control in the laboratory, and in particular with geometric and mechanical measurements.

The eight chapters cover: control and measurement, choice of test, laboratory organization; statistics applied to testing and control; measuring instruments and machines; geometric measurement; mechanical measurement; extensometry, the measurement of deformation and strain; equipment for mechanical testing.

There are long bibliographies included in each chapter. As one expects from Mr. l'Hermite and his colleagues, this is a detailed work, embodying their own experiences, and the series should prove of great value to all those concerned with materials testing. (R. l'Hermite and others. Paris, Eyrolles, 1959. 739 p., 9,965 fr.)

TRAITE DE MACHINES A COMBUSTION INTERNE: T. I., THERMODYNAMIQUE

The first of a series of five volumes to be published on the internal combustion engine, covering all aspects of the subject, and emphasizing particularly the different types of engine in use, their evolution and possibilities.

In this volume, the author analyzes the basic principles of thermodynamics, required for the study of any engine. He illustrates the application of thermodynamics to the internal combustion engine, and includes tables of thermodynamic constants of the principal chemical components of combustion, up to 5000° K. (M. Serruys. Paris, Dunod, 1959. 250 p., 3,800 fr.)

LES UTILISATIONS DU GAZ NATUREL

Natural gas has been used in the southwest section of France for the last ten years and the discovery of the reserves at Lacq, and the development of the Sahara fields, mean that natural gas will now be available to consumers in large areas of France.

Introductory chapters outline the physico-chemical and thermal characteristics of natural gas, and succeeding ones consider the use of natural gas in various fields. These include: steam production, the iron industry, glass-making, cement works, brick and tile making, and furnaces. The use of gas as a fuel in diesel engines, turbines, and compressors is considered, as are chemical applications, and domestic use. A final chapter discusses safety measures.

The book is translated from the Italian, and examples are given of both Italian and American applications. (M. Medici. Paris, Dunod, 1959. 241 p., 3,600 fr.)

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race St., Phila. 3, Pa.

1959 compilation of ASTM standards on copper and copper alloys. 720p. $7.50.
ASTM standards on metallic coated iron and steel products. 176p. $3.50.
ASTM standards on methods of atmospheric sampling and analysis. 112p. $2.25.
1959 supplement to book of ASTM standards including tentatives. Part 1, Ferrous metals; Part 2, Non-ferrous metals; Part 3, Methods of testing metals; Part 4, Cement, concrete, mortars, road materials, waterproofing, soils; Part 5, Masonry products, ceramics, thermal insulation, acoustical materials, sandwich and building constructions, fire tests; Part 6, Wood, paper, shipping containers, adhesives, cellulose, leather, casein; Part 7, Petroleum products, lubricants, tank measurement, engine tests; Part 8, Paint, naval stores, aromatic hydrocarbons, gaseous fuels, engine antifreezes; Part 9, Plastics, electrical insulation, rubber, carbon black; Part 10,

Textiles, soap, water, atmospheric analysis, wax polishes.

CSA standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2.

0 112 series-1960: Specifications for wood adhesives.

0 115-1959: Specification for hardwood plywood. 2d ed. 75c.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Bridges, Highway

Highway bridge vibrations: Part 1. A review of previous studies, by D. T. Wright and R. Green. Kingston, Ont., Queen's University, 1959. (Report no. 4.)

Canada. Dept. of Mines and Technical Surveys

Bibliography of periodical literature on Canadian geography, 1930 to 1955; part 4, Prairie provinces. 1959. 50c. (Geographical Branch Bibliographical series no. 22.)
Metallurgical works in Canada; non-ferrous and precious metals. 1959. 25c. (Mineral Resources Division Operators list 1, part 2.)
A survey of the steel pipe and tube industry of Canada, by T. H. Janes. 1959, 50c. (Mineral Resources Division Bulletin MR 36.)
The Canadian gypsum industry, by R. K. Collings. 1959. 25c. (Mines Branch IC 114.)
Vacuum degassing of steel: Part 1: Literature survey, and preliminary work, by D. E. Parsons and W. A. Morgan. 1959. 25c, (Mines Branch Research Report R 47.)
Radioactive marking of steel balls for grinding tests, by G. G. Eichholz. 1959. 25c. (Mines Branch Technical Bulletin TB 12.)

Canada. National Research Council. Division of Building Research

Annotated bibliography on vane testing in soils, compiled by J. J. Hamilton. 1959. (Bibliography no. 17.)
Muskeg research: a Canadian approach, by I. C. MacFarlane. 1959. 25c. (Technical paper no. 83.)
An investigation into processes occurring in solifluction, by P. J. Williams. 1959. 25c. (Research paper no. 84.)
Evaluation of factory-sealed double-glazed window units, by A. G. Wilson and others. 1959. 25c. (Research paper no. 85.)
Snow load on buildings; translations of seven Russian papers, translated by D. E. Allen. 1959. (TT 830.)
A new waste disposal system, by E. Lindstrom and tr. by H. A. G. Nathan. 1959. (TT 838.)
Quick soils and flow movements in landslides by E. Ackermann and tr. by D. A. Sinclair. 1959. (TT 839.)

Canada. National Research Council. Division of Mechanical Engineering

Powerplants for VTOL aircraft: a proposed dual-operation system using wing-immersed fans for vertical thrust, by E. P. Cockshutt and N. Galitzine. 1959. (Aeronautical Report LR-265.)
On the transfer of heat from a river to an ice sheet, by W. D. Baines. 1959. (MH-93.)

Columns. Concrete.

Design of long reinforced concrete columns. N.Y., Reinforced Concrete Research Council of the Engineering Foundation, 1959. (Bulletin no. 11.)

Directories.

American Public Works Association Yearbook, 1959. Chicago, 1959. $5.00.
F.B.I. Register of British Manufacturers, 1960. 32nd ed. London, 1959. 42s.

Engineers

Criteria for professional employment of engineers. Montreal, Corporation of Professional Engineers of Quebec, 1959.

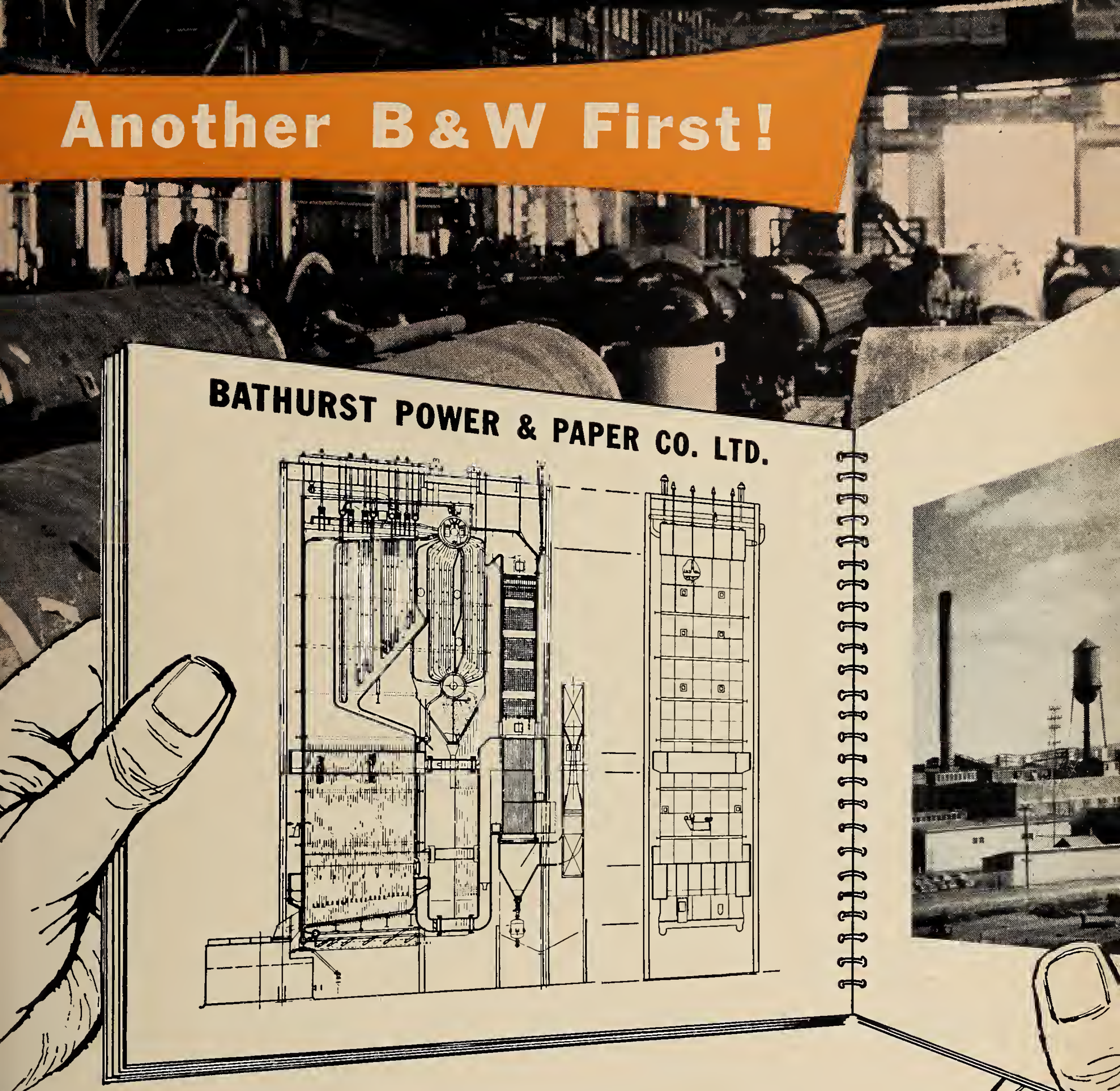
Fuel research

An investigation of the mechanism of the oxidation, decomposition, ignition and detonation of fuel vapors and gases, parts 1-30, 1947-1957, by R. O. King and others. Ottawa, Dept. of National Defence, Defence Research Board, 1959. (Reprints from the Canadian Journal of Research (1947-1950) and the Canadian Journal of Technology, (1951-1957.)

Industrial management

Systems and procedures responsibility, by P. H. Thurston. Boston, Harvard School of Business Administration, 1959. $2.50.

(Continued on page 195)



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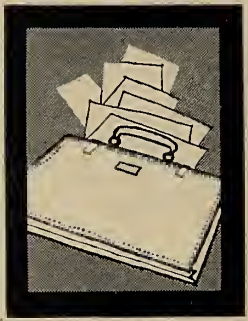
Business and International Briefs



Appointments and Transfers

The appointment of F. J. O'HARA and J. G. SUTHERLAND as Vice Presidents reflects the growing importance of the Technical Products and Tube Divisions in R.C.A. Victor's Operations.

Canadian Liquid Air announces three appointments. JAMES E. WILKIN becomes Secretary-Treasurer, M. V. BREBER is named Assistant Treasurer, and GORDON C. NAYLOR is now Manager of the Control Division.

STONE & WEBSTER announces the appointment of E. B. HYMMEN as Chief Engineer.

ROGER DUVAL has been appointed Manager, Municipal Sales, Quebec, for Canada Iron Foundries, Limited.

CANADIAN FAIRBANKS-MORSE announces the election of WILBUR WRIGHT as Vice President, Engine and Pump Division. He will be nationally responsible for the application, sales and service of the Company's full line of diesel engines and hydraulic equipment.

Canadian General Electric has appointed ARCHIE JOHNSTON as Manager, Quebec District, for the Wholesale Department.

K. C. CULHAM, President of Empire-Hanna Division, The M. A. Hanna Company, was elected President of the Bituminous Coal Institute of Canada at the recent Annual Meeting held in Windsor.

Canadian Westinghouse has been honoured by the election of ARTHUR A. RYAN as President of the Graphic Reproduction Association.

Business News

FOR FINDING LEAKS in enclosures that can be pressurized, with the aid of halogen leak detectors, Canadian General Electric has issued a six-page booklet: G.E.T.-2936. A portable electronic leak detector equipped with special probe is available from General Electric. Typical uses would be during the installation of large commercial and shipboard air conditioning systems, and any checking for refrigeration leaks in confined, unventilated devices such as vending machines.

STRICTLY NO GUN, but a hand tool, is the DX100L, latest addition to the Hilti range of methods for direct fastening into concrete, brick and steel. It operates with or without a cartridge. Although the cartridge strength is only half as much as the gun-tool cartridge, a pull of 2000 lbs. average is needed to extract the Hilti DX studs or pins, part of the equipment supplied by Crowther Ltd. of Westmount, P.Q.

TO SUSPEND CEILINGS in Shell's new 26-storey office building in London, England, "Chevron" slotted angle was chosen. Within the ceiling cavities are housed the air conditioning ducts and units, heating elements, electric conduits and cables, and these too are suspended by means of Chevron angles. Chevron's unique ability to fit together at any point and provide an infinite variety of bolting positions, no matter how joined or cut, derives from the constantly repeated chevron shaped slots in its design.

WORN SOCKETS are more quickly replaced when the compact 16 lb. portable tube tester introduced by Stark Electronic Sales is used. The tester checks filament voltages in 18 steps from U.6 to 117 volts, and the new socket design slips off easily, exposing an 11 pin socket.

A PUSH-BUTTON SWITCH for mass production has been produced by a British company. This type of precision switch has been the subject of American research and will be a unique addition to the wide range of multi-channel equipment now used in a wide variety of industries. Seton-Creaghe of London are designers and producers of the switch, which is especially suited to high-frequency applications and is designed to reduce maintenance and the likelihood of mechanical breakdown. The prototype is being tested to a life of one million operations.

THE LARGEST CAPACITY in Canada is claimed for the new British-American Oil gas processing plant which will soon appear on the Alberta prairie near Rimbey, 50 miles south of Edmonton. A group of 25 owner companies, all with production interests in the Dick Lake or Homeglen Rimbey fields, has designated British American Oil as plant operator, responsible for the construction, maintenance and continuing operation of the $12.5 million plant which will process up to 326 million cubic feet of gas daily.

PRESTRESSED AND PRECAST concrete uses and techniques were the subject of a recent tour sponsored by Supercrete of Winnipeg. A party of over 75 Canadian architects and engineers visited England, Italy, Belgium and France to see what is being done these days in this area of major construction.

SUPERSONIC SPEEDS and the aerodynamic shapes associated with them have brought the risk of skin friction causing spontaneous combustion of fuel and increased the similar risk from lightning. An explosion supression system developed by the British Oxygen Group used liquid nitrogen injected into the air bled from the engine compressor, which pressurizes the fuel tanks thus making the gaseous mixture in the tanks chemically inert. The system, which has the obvious advantage of being continually in operation, can be readily integrated with existing installations. It weighs only 12 lbs. for every thousand gallons of fuel carried.

A BULGE in the line is virtually all that is seen of a small rotary gas meter announced by Roots-Connersville, a division of Dresser Industries. Employing a new concept in rotary-type positive displacement gas meter design, and aimed at providing accurate metering at low cost, the 3M125 meter flange can be mounted directly in either a horizontal or vertical gas line without additional support, and provides straight-through gas flow.

DELIVERY IS LIMITED automatically to system demand at pre-selected adjustable pressures by Vickers Incorporated's new 6 gpm variable vane pump. Sharp cut-off characteristics enable the pump to deliver nearly full volume up the compensator setting even at low operating pressures. It is ideally suited as a fluid power source for varying volume demand circuits.

NUCLEAR PARTICLE detection research by R.C.A. Victor in its Montreal laboratories has resulted in the developing of a new semiconductor device which can detect the presence and measure the energy of alpha-particles emitted from radioactive materials. This work has previously been done by scintillation or Geiger counters, both of which require batteries or power supplies giving several hundred volts. Unlike these the semiconductor alpha-particle detector operates from a low voltage supply like a transistor and thus opens up a whole new set of interesting possibilities for miniature portable detection systems. It is extremely robust and relatively cheap, and can therefore be used where existing detectors are either too fragile or too expensive.

NICKEL TRANSDUCERS, which change alternating electrical energy into ultrasonic vibration, are being used for the ultrasonic cleaning of intricate assemblies including meters and guidance components for missiles, and are being employed in underwater sound devices for depth finding, detection and related purposes. A recently introduced nickel alloy containing 4% cobalt, which provides superior performance, is used extensively in this equipment.

A COMPACT TESTER announced by Canadian General Electric is designed for easier testing and servicing of 720 cycle carrier controllers used by electrical utilities for peak load control. This tester features 720 cycles for calibrating or timing the circuit, as well as the mixing of 720 cycle with 60 cycle for operational testing. The cathode ray tube gives visual indication for the adjustment of 720 cycles. The tester can be supplied with or without a test voltmeter.

ONTARIO sales and service of Dominion Power Cranes & Shovels have been taken over by the Construction Equipment Company, Limited. The Dominion plant at Montreal is one of the largest and most diversified of its type in North America.

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EASY ADJUSTMENT to produce a not-yet-determined optimum feed size for autogenous grinding mills is a feature of the 60-89 inch gyratory machine being supplied to Iron Ore Company of Canada by Canadian Allis-Chalmers. Hydraulic adjustment of the crushing head is the feature which will provide this advantage in the primary crushing of iron ore at Wabush Lake.

GALLIUM ARSENIDE, a little known semiconductor material, has enabled General Electric to produce tiny electronic parts (tunnel diodes) which will work at frequencies above four billion cycles. Gallium Arsenide tunnel diodes have current densities of 5,000-10,000 amp. per sq. cm. By comparison, the current density of 12 gauge housewire is 7,000 amp. per sq. cm.

MONTREAL ARMATURE WORKS has been taken over by General Electric, and will come within the responsibility of the Apparatus Department.

A NEW LINE of electronic testing equipment, manufactured in Scotland by Allscott Electronics, is being introduced to the Canadian market by Ferranti-Packard Electric Limited. The line includes noise measuring equipment and a spectrum analyser.

BY 1970 there may be about 290 lb. of aluminum in every car, according to Dr. G. E. Willey, Vice-President of Electro Metallurgical, a division of Union Carbide. "The experimental stage for the incorporation of aluminum in the automobile is past; it is now only a question of time until its general applications will become standard." Electro Metallurgical has expanded facilities at its Beauharnois and Welland plants.

FOR INJECTION MOULDERS to receive the best possible service on products is the objective of the DuPont Plastics Division as preparations go forward for producing high-density polyethylene resin at St. Clair River works. Under this policy, Canada Colours and Chemicals Ltd. has been appointed as a distributor to compliment the services of the DuPont sales force.

TO INCREASE SAFETY and improve on-time performance, C.N.R. has introduced a two-way radio communications system from Vancouver and Prince George to Edmonton. The new system enables train crews and despatchers to obtain immediate information on track conditions and emergency situations.

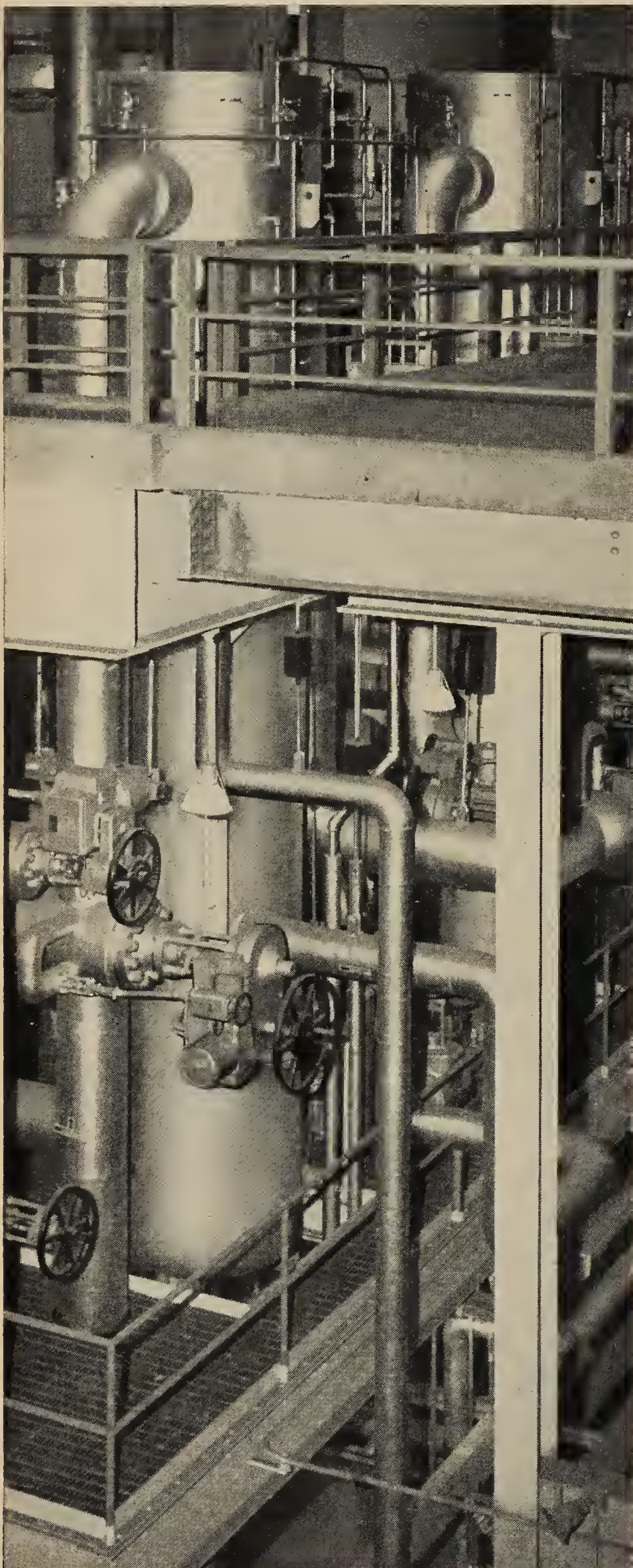
POLYDYNE DRIVES, an entirely new line of packaged adjustable speed drives has been announced by General Electric. The new series represents the first mechanical adjustable speed drives to be offered by the Company's Apparatus Department. Polydyne Drives, available in a wide range of outputs and speed ratios, operate on the principal of V-belt-connected adjustable pitch pulleys. Field trials have brought favourable reports on simplicity of belt changing and smooth operation of the stepless control mechanism.

THE LAST CONTRACT for major dredging at Cornwall on the St. Lawrence Power Development has been awarded to McNamara Construction of Toronto, Ontario Hydro announces. McNamara's bid of $3,666,470 was the lowest of five tenderers. The contract calls for excavation of an estimated 1,363,000 cu. yd. of material from an area extending downstream from the powerhouses for approximately 5000 ft. on both sides of the international boundary.

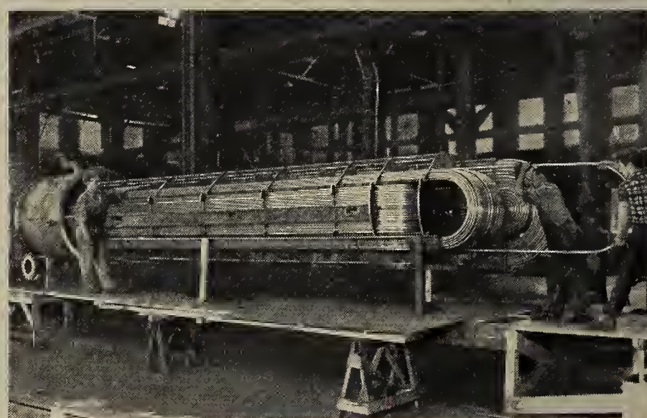
THE ALUMINUM INDUSTRY foresees a lively and widespread interest in the new Alcan aluminum guyed tower design for transmission line construction. Four years of design study followed by more than a year's intensive development and test work have produced an attractive structure of considerable versatility. Made up of components that can be erected in either of two arrangements to suit conditions of terrain and right-of-way, the Alcan aluminum guyed tower can be erected on a single base in the form of a V or on twin bases with parallel uprights.

FOR ECONOMICAL magnetic recording and monitoring in the field, Southwestern Industrial Electronics has introduced the MS-15A Magnetic Recording and Monitoring System, equipped with 24 broad-band, linear phase-shift seismic amplifier-FM modulator combination channels. Bridged-T hi-line filters are available, and the equipment is easily installed in a portable recording cab.

CANADA'S LARGEST FEEDWATER HEATERS ...BUILT BY M.L.W.



MLW Feedwater Heaters installed at Richard L. Hearn Power Station.



Shop assembly of MLW Feedwater Heater.

These are the largest feedwater heaters ever made in Canada. Designed for Canada's largest power station, these heaters were built by Montreal Locomotive Works.

Now installed at the Richard L. Hearn Generating Station of the Hydro-Electric Power Commission of Ontario, they incorporate the exclusive Alco High Pressure Closure. This exclusive Type "D" high-pressure closure means easier maintenance than ever before. It is simple, economical and highly effective. It can be dismantled and assembled with a minimum of small tools.

These units are typical of MLW's leadership in the manufacture of heat transfer equipment, and typical also of MLW's manufacturing scope in designing and building equipment for a wide variety of Canadian industries.

Consulting Engineers:
Stone & Webster Canada, Limited

MLW

MLW INDUSTRIES DIVISION
MONTREAL LOCOMOTIVE WORKS LIMITED

• LIBRARY NOTES

(Continued from page 174)

Industrial plants. Pilot plants.
The pilot plant of the Department of Mines of the Province of Quebec. Que., Dept. of Mines, 1960.

Industrial relations.
Outstanding books in industrial relations, 1959. Princeton, N.J., University, 1960. (Selected references no. 92.) 30c.

Irrigation.
A century of irrigation, Godavari-Krishna Deltas, 1859-1959. Andhra Pradesh, Hyderabad, Institution of Engineers (India), 1959.

Modular coordination (architecture).
Modular coordination in practice; a record of four speeches for architects, contractors, and manufacturers. Ottawa, N.R.C., Div. of Bldg. Research, 1959. (Technical paper no. 79.) 50c.

Magnetism
Advanced magnetism and electromagnetism, ed. by A. Schure. N.Y., Rider, 1959. $2.50.
Magnetic and electrical fundamentals; Franklinian approach, by A. Efron. N.Y., Rider, 1959. $2.50.
Magnetism and electromagnetism, ed. by A. Schure. 1959. $1.80.

Moon.
Moon base; technical and psychological aspects, by T. C. Helvey. N.Y., Rider, 1960. 72p. $1.95.

Road machinery. Rollers.
Investigation of the performance of pneumatic-tyred rollers in the compaction of soil, by W. A. Lewis. London, Dept. of Scientific and Industrial Research, Road Research Laboratory, 1959. (Technical paper no. 45.) 3s.6d. (63c)

Rubber.
Compounding natural rubber for service at low temperatures by S. G. Fogg and P. M. Swift. London, British Rubber Producers' Research Association, 1959. (Technical bulletin no. 4.)

Shaft sinking. Bibliography.
Deep mine shafts; a collection of annotated bibliographies pertaining to shaft sinking by freezing methods, shaft grouting, shaft linings, and concrete design, by A. D. Scharf. Saskatoon, Sask. Research Council, Div. of Information Services, 1959.

Soil mechanics.
Notes on the shearing resistance of soft clays, by J. Osterman. (ACTA Polytechnica Scandinavica, Civil engineering and building construction series 2, 1959. 24p.)
Landslide and foundation investigations and stability analysis. Wash., National Research Council, Highway Research Board, 1960. (Bulletin no. 236.)

• OTHER SOCIETIES

(Continued from page 148)

- May 18-20 —Society for Experimental Stress Analysis Meeting, ("Stress Analysis of Propulsion Systems"), Indianapolis, Ind.
- May 22-26 —ASP National Planning Conference, Miami Beach, Fla.
- May 30-31 —Wire Reinforcement Institute Spring Meeting, White Sulphur Springs, W. Va.
- June 1-4 —Institution of Austrian Architects, Consulting and Civil Engineers and The Austrian Chambers of Engineers, 100th Anniversary Congress, Vienna.
- June 13-15 —43rd Canadian Chemical Conference and Exhibition (Chemical Institute of Canada), Ottawa.
- June 14-16 —DECHEMA Annual Meeting, 26th Meeting of The European Federation of Chemical Engineering, Frankfurt.
- June 15-25 —International Conference on Large Electric Systems, Paris
- June 26-July 1 —American Society for Testing Materials Annual Meeting, Atlantic City, N.J.
- August 8-11 —American Astronautical Society Western National Meeting, Seattle, Wash.
- Sept. 13-15 —Fifth International Conference on Instruments and Measurement, Stockholm.
- Sept. 19-30 —Technical Report Writing Seminar, Pennsylvania State University.
- Sept. 26-30 —National Material Handling Show and Conference (American Material Handling Society, Montreal Chapter), Montreal.
- Sept. 27-30 —Prestressed Concrete Institute Annual Convention, New York, N.Y.
- Nov. 8-10 —Conference on Non-Destructive Testing in Electrical Engineering (Institution of Electrical Engineers, U.K.), London.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

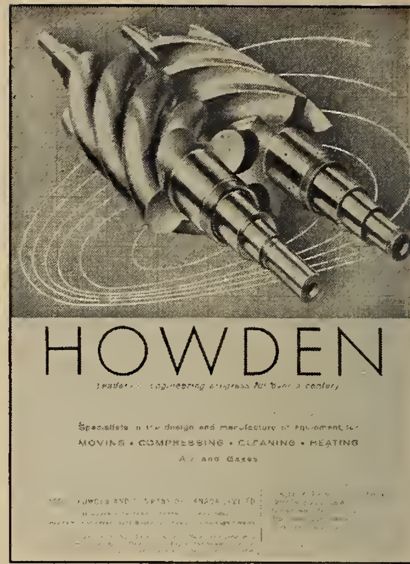
The James Howden & Company of Canada Limited 3-colour advertisement which appeared on the inside-back-cover of the January 1960 issue was judged the "best", in that issue, by a jury of fifty readers.

The illustration shows the rotors of a new screw compressor which pump at a compression ratio up to 5:1.

The advertisement has great "attention-getting" value as it combines excellent artwork with a dominating combination of red, yellow, grays and black.

James Howden & Company of Canada Limited have their head office and plant at 1510 Birchmount Road, Scarborough, Ontario and branches in Vancouver, Calgary, Toronto and Montreal. The Managing Director of the company is W. MacOwan. The advertising agency who prepared and placed the advertisement is Chris Yaneff Ltd. of Toronto.

Reproduced here, on a reduced scale, is the 3-colour advertisement which was judged the "best" in the January issue, from the viewpoints of ACCURACY — INFORMATION and ATTRACTION, by the fifty readers who were asked to evaluate the advertisements. The James Howden advertisement appeared on the inside-back-cover of the issue. It is printed in three colours — black, yellow and red.



JAMES HOWDEN AND COMPANY OF CANADA LIMITED WINS CERTIFICATE OF AD MERIT

• MORE ABSTRACTS

The Economics of An Industrial Gas Turbine Installation
D. Panar, M.E.I.C.

Economics of power generation, emphasizing variable costs and peak power costs. Utility interconnection, demand and stand-by charges. Feasibility of private interconnected generation with various types of prime movers. The particular properties of the gas turbine. Possibility of by-product energy. Analysis of the University of Alberta's problem and solution. Economical loading of the system, present operating experience and future trends.

Economic Aspect of Industrial Power Plants
Howard R. Wright, M.E.I.C.

It is difficult to predict whether the generation of power will be profitable in an industrial plant without detailed feasibility studies. Ratio of process steam to process power used as general guide. Bulk of capital and operating charges belong to production of process steam. Incremental cost for high pressure and temperature boiler design are chargeable to power generation. Charts give estimated costs. Typical total power cost calculations. Comments on recent wood/oil-fired installations for power production.

The Khulna Newsprint Project
D. P. Wyness

The first mill to produce newsprint and mechanical printing papers in Pakistan commenced production in July 1959. Experimentation with the tropical hardwood, gewa, as a pulpwood showed that the chemi-groundwood process was best suited to the project. The demand for newsprint by 1962 has been estimated at 23,000 and for printing papers, at 41,000 long tons. Sandwell and Company, Limited, Vancouver, completed construction of the mill in July 1959 and for 18 months managed its operations.

The Potential in the Free-Piston Engine Principle
Anton Braun

The unused potential in the free-piston engine principle can be compared to the potential remaining in conventional engine principles of today. Early models of free-piston engines represent conservatively designed units. Today's free-piston engines must be considered as in early development stages, whereas modern spark ignition and compression ignition engines are close to the limits of their respective principles.

Soil Problems in Mining on the Canadian Shield
R. F. Legget, M.E.I.C., and *W. J. Eden,* JR.E.I.C.

Soils found in mining operations on the Canadian Shield are almost all glacial in origin and range from well-drained sand and gravel deposits to silts and clays deposited in glacial lakes. Description of typical glacial clays and explanation of their unusually high moisture content. Successful handling of these materials; erection of mining structures upon them.

Western Canada Potash and Its Future Prospects
W. J. Pearson

Manitoba and Saskatchewan potash is of higher quality than that being mined in New Mexico and Europe. The first company to explore these deposits finished its shaft in 1958 and the first shipment was in March 1959. Excessive inflow of water into the shaft caused a shutdown in November. By January 1, 1960, 16 companies representing five national interests had holdings. Canada's potash prospects are good. Consumption throughout the world is on the increase and reserves elsewhere are being deplenished.

THE ENGINEERING JOURNAL

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA VOLUME 43 NUMBER 5 MAY 1960

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Printed in Toronto

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and Technology Index

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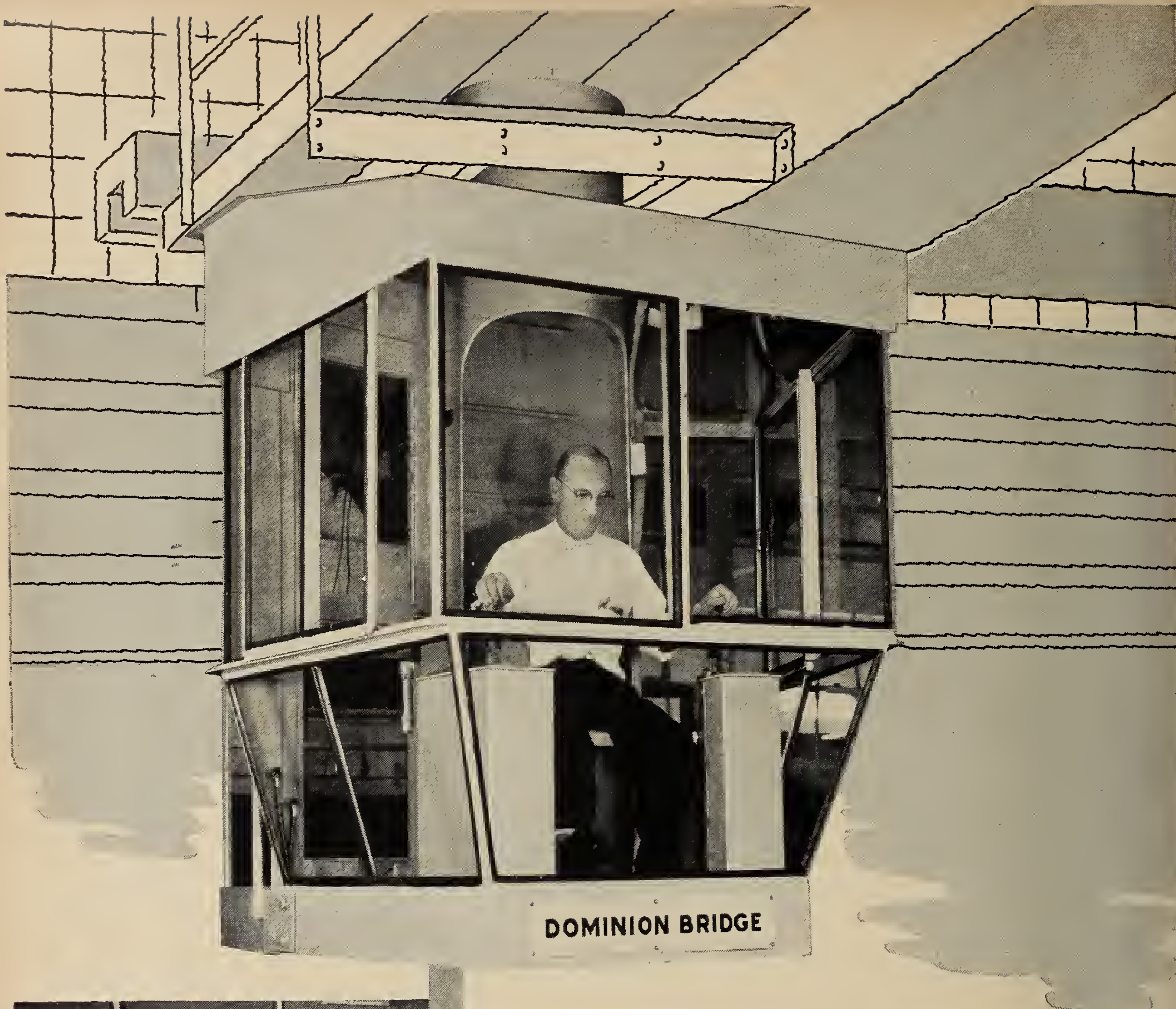

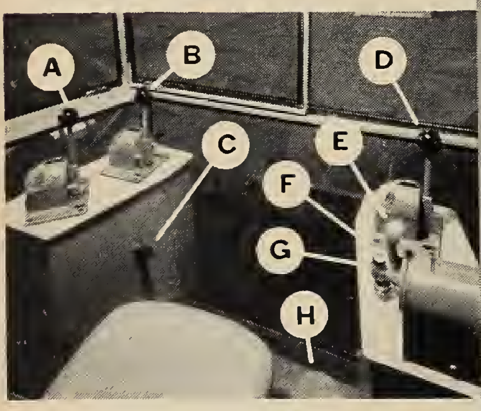

(A) Bridge travel control **(B)** Trolley travel control **(C)** Warning siren button **(D)** Hoist control **(E)** Lifting magnet control **(F)** Emergency stop button **(G)** Reset button **(H)** Bridge brake pedal.

YOU CAN SEE IT'S SAFER!

Better visibility, more convenient control and less operator fatigue are principal features of this new Dominion Bridge crane cab. No longer is it necessary for the operator to stand and look over the side for close-to lifts—he can see the whole operation from his seat. This is more efficient and safer.

Other improved features include a completely enclosed access ladder to the bridge walkway from inside the cab; a non-slip floor; non-glare internal paintwork; a seat designed for greater comfort, and a control set-up conveniently grouped for easy operation. Heating and/or air conditioning can be supplied as optional extras. Open type cabs are also available.

The design of Dominion Bridge cranes is always under review and new improved features such as these are added as they are proven satisfactory. Dominion Bridge manufactures cranes of all types from the small ½-ton hoist to machines capable of lifting several hundred tons.

cranes by

DOMINION BRIDGE

20

FOURTEEN PLANTS—COAST TO COAST

Meet the Authors

L. H. Chater, B.Sc., Civil (Saskatchewan '32), Chief Engineer, The Steel Company of Canada, Ltd., Hamilton. *(Some Major Problems in Steel Plant Engineering for Growth at Stelco).*

Mr. Chater joined a firm of consulting engineers London, England in 1936 and later came to Canada as a design engineer with Ontario Hydro. In 1947 he joined Stelco as design engineer, became Assistant Chief Engineer, then Chief Engineer, Hamilton, and was appointed chief engineer of all works of the company in 1957. He is a member of The Association of Professional Engineers of Ontario, The Association of Iron & Steel Engineers and the American Iron & Steel Institute.

G. L. MacKenzie, M.E.I.C., B.Sc., Civil (Queen's '19), Director, Prairie Farm Rehabilitation Branch, Canada Department of Agriculture, Regina, Sask. *(The South Saskatchewan River Dam).*

Mr. MacKenzie worked for consulting engineers in Saskatoon for 14 years before joining the Federal Department of Public Works. Chairman of the Prairie Provinces Water Board and Canadian Chairman of the International Engineering Board, he is also Chairman of the Federal Provincial South Saskatchewan River Development Board. He is a registered Professional Engineer of Saskatchewan.

A note on **J. W. MacLaren** appeared in the April 1960 issue of The Engineering Journal.

D. B. Clement, M.A. Mechanical (Cambridge '52), Project Engineer, James F. MacLaren Associates, Consulting Engineers, Toronto, Ontario.

N. D. Pappas, M.E.I.C., B.A. Sc. (Toronto '48), Associate, James F. MacLaren Associates, Consulting Engineers, Toronto, Ontario, (*A Deep Pumping Station for the Ottawa Sewage Treatment Plant*).

Upon graduation, Mr. Clement was employed by consulting engineers in London, England. In 1957, he came to Canada and joined the Montreal Engineering Co. Ltd. He is a member of the Corporation of Professional Engineers of Ontario and an associate member of the Institute of Civil Engineers, Great Britain.

Mr. Pappas was with the Welland Canal staff of the Department of Transport, St. Catharines, Ontario, and left his position as Assistant Superintending Engineer in 1956 to join his present firm. He is a member of the Corporation of Professional Engineers of Ontario.

T. Ingledow, M.E.I.C., B.Sc., (Glasgow), M.A., D.Sc., President, International Power and Engineering Consultants Limited, Vancouver, B.C. (*Some Features of the Port Mann Gas Turbine Generating Station*).

Dr. Ingledow served in various engineering executive capacities in Canada and the U.S. until 1940 when he joined the B.C. Electric Company Ltd., in Vancouver. In April, 1960, he retired to take up his present position.
A past member of the Defence Research Board of Canada, he has also served with B.C.'s Columbia River Basin Development Committee and the Governor's Power Policy Committee of the Northwest United States of America. He is a Past-President of the Canadian Electrical Association, the Association of Professional Engineers of B.C., and the Northwest Electric Light and Power Association, and a Fellow of the American Institute of Electrical Engineers.

W. S. Watson, B.Sc., Electrical (Manitoba '45), Electrical Engineer, The Shawinigan Engineering Company Ltd., Montreal.

V. Gabruss, Dipl. Ing., Electrical (Institute of Technology, Munich '47), Electrical Engineer, The Shawinigan Engineering Company Ltd., Montreal. *(Remote Control of Dufferin Falls Generating Station).*

Mr. Watson was with the English Electric Company of Canada Ltd. until 1949. A Member of the Corporation of Professional Engineers of Quebec, he is also an Associated Member of the American Institute of Electrical Engineers.

After graduation Mr. Gabruss worked with "AEG", Stuttgart, Germany until 1949 when he joined the H. G. Acres Company, Consulting Engineers, Niagara Falls. He is a Member fo the Association of Professional Engineers of the Province of Ontario and a Member of the Latvian Engineers Association.

J. C. Thomson, B.A.Sc. Mechanical (U.B.C. '48), Research Engineer, Production Research and Technical Service Laboratory, Imperial Oil Limited, Calgary, Alberta. (*Vehicles in Muskeg*).

Mr. Thomson was with the National Research Council for two years in the Division of Mechanical Engineering, Engine Laboratory. He spent six years with the Defence Research Board in charge of the Soil and Snow Mechanics Group and Vehicle Mobility.

R. F. Legget, M.E.I.C., M.Sc., Civil (Liverpool '25), Director, Division of Building Research, National Research Council, Ottawa. *(Engineering Astride the Border.)*

Mr. Legget came to Canada in 1929, joined the staff of Queen's University in 1936 and, in 1938, the University of Toronto. He later went to Ottawa to start the new Division of Building Research of the N.R.C. and has been Director since 1947. A Member of the Institution of Civil Engineers and the American Society of Civil Engineers he is also a Fellow of the Royal Society of Canada, the Geological Society of America, and an Honorary Fellow of the Royal Architectural Institute of Canada.

J. Zorzi, M.E.I.C., B.Sc., Civil '39, Consulting Engineer, St. Eustache Sur-le-Lac, Que. (*Cofferdam at Mile 6 Quebec Cartier Mining Railroad, Port Cartier, Quebec*).

Before starting out as a consultant in 1945, Mr. Zorzi had wide experience on structural design, soil mechanics, hydraulic developments, mining, heavy construction, welding and marine engineering, and is now studying nuclear engineering. He is a Member of the Corporation of Professional Engineers of Quebec.

COVER ILLUSTRATION

The Steel Company of Canada sent us this picture of the tapping of steel from an open hearth furnace.

OIL MINIMUM CIRCUIT BREAKERS

GET THE "WHY" BEHIND THESE 104 CANADIAN INSTALLATIONS

The 104 ASEA oil minimum circuit breakers installed in Canada to date, are being augmented this year by many repeat orders resulting from initial satisfaction.

We have excellent descriptive literature on the operating principles of oil minimum breakers. You will also find interesting a report on field tests of the full short circuit ratings of 138 KV units. May we send these to you? Write: Canadian ASEA Electric Limited, P.O. Box 670, Station "B" Montreal.

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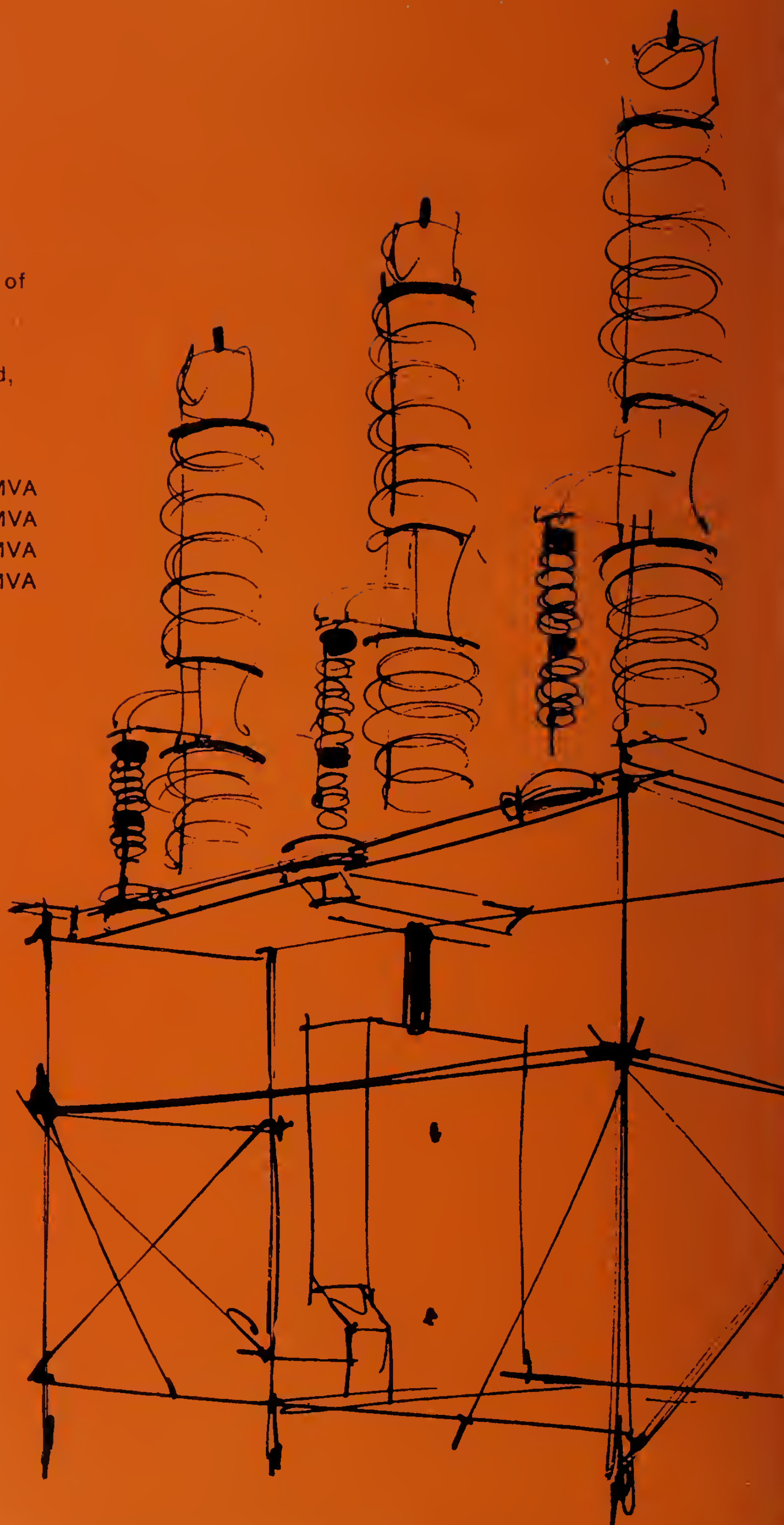


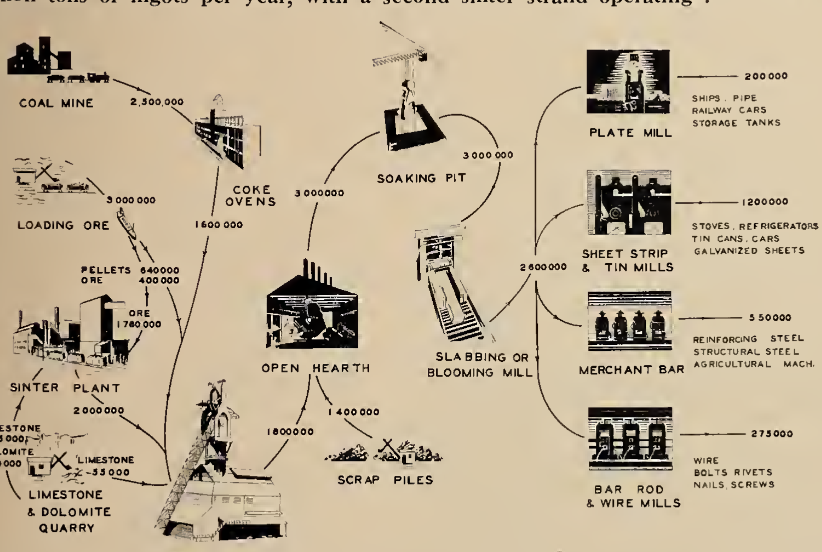
SOME MAJOR PROBLEMS IN STEEL PLANT ENGINEERING FOR GROWTH AT STELCO

L. H. Chater, *Chief Engineer, The Steel Company of Canada Limited, Hamilton*

Most people are under the impression that the steel industry's main job is to make and erect steel shapes for large buildings and bridges and to produce steel for cars. It is perhaps a natural misconception since these are the items which attract attention and therefore make an impression. Actually, no Canadian steel producer is in the fabricating and erecting business and only 25% of the total tonnage of steel produced in Canada goes into the above items. The largest proportion of steel is used to produce other items which are so much a part of our everyday life, such as tin cans, stoves, refrigerators, washing machines, pipe, wire, nails and screws, to mention a few. The Steel Company of Canada alone produces 300 finished lines, but the greater part of the semi-finished steel it produces is used by secondary industries.

FEW PEOPLE stop to think about what goes into the manufacture of steel and how it is produced. However, it is not the purpose of this paper to go into the intricate chemical reactions or the varied metallurgical aspects in the manufacture of steel, rather it will be principally confined to one of the most important aspects of the steel plant engineer's job — materials handling. But a brief knowledge of the various steps in the production of steel and their sequence is necessary to grasp the magnitude of the materials handling problems involved. Fig. 1 shows the flow of materials through the various steps in a typical integrated steel plant as well as some of the products manufactured by secondary industries from the various forms of semi-finished steel. An integrated plant is one which contains all the processes necessary to produce semi-finished steel, such as sheets and bars, from the basic raw materials iron ore, coal and limestone. The Hamilton Works of The Steel Company of Canada is typical. Individual steps may vary depending principally on raw material conditions [1], but most steel is made by the process sequence used by Stelco, as indicated in Fig. 1.

Fig. 1. Illustration of the steps required to produce steel in its various forms. The yearly flow of material between processes is shown for Hamilton Works producing 3 million tons of ingots per year, with a second sinter strand operating .



MATERIALS HANDLING

When the present expansion program at Hamilton Works is completed in 1960 steel ingot capacity will have grown from 1.25 million tons in 1951 to 3 million tons per year. Facilities at ore properties and Hamilton Works to produce this increase in steel ingots and the additional facilities required to treat and form the ingots into semi-finished steel forms will have involved a capital expenditure of about $230 million. The importance of materials handling in a steel plant can be realized when it is considered that a large proportion of this cost has gone directly and indirectly into materials handling. The importance of efficient handling looms even larger when it is considered that 40% of all production costs within a steel plant are taken up in the handling of materials. Since these costs add nothing to the value of the product the challenge to the plant engineer is obvious, especially when one realizes that it is the only major area remaining for substantial cost reduction.

There are certain basic considerations which the engineer must keep constantly in mind when planning and designing handling facilities in a steel plant.

1. Since steelmaking is a continuous 24 hr. daily operation and the various units in the process are interdependent, the flow of material must be reliable. The required amount of each item must be available at its destined location at the required time.

2. It follows that the prime consideration in laying out new units, or extending those already existing, is the dependability of getting materials to and away from those units.

3. Adequate surge reserves must be provided between those units in the process which, in the event of a breakdown, would otherwise shut down all subsequent operations.

4. Alternate handling methods must be available for vital links in the handling chain.

5. In general, within physical capabilities, the larger the pay load the smaller the unit handling cost.

6. Adequate provision must be made for future expansion and to take care of increasing loads as the various units grow in output.

7. So far as practical handling facilities must be flexible to take care of forseeable changes in the steelmaking process.

8. Capital costs must be balanced against operating costs to ensure the most economical facility.

With these points in mind let us follow the steelmaking sequence in looking at some of the handling problems involved in recent expansions at Stelco.

Ore & Coal Handling & Storage Facilities

To produce the iron required in the manufacture of 3 million tons per year of steel ingots the blast furnaces consume 3 million tons of iron ore, 2.5 million tons of coal in the form of coke, and 700,000 tons of limestone and dolomite. Since ore and coal are delivered in Great Lakes freighters they must all be brought in and unloaded during the shipping season (1st April to 15th November). In addition, adequate storage must be provided to keep the furnaces going during the winter when shipping cannot operate.

In 1951, to keep pace with the growing demand for steel in Canada, Stelco decided to increase its steel capacity. This meant providing not only open hearth furnaces, but a new blast furnace with sustaining coke ovens and raw materials handling and storage facilities. Unfortunately the only location for storage facilities which would meet the requirement of easy access to both the coke ovens and blast furnaces consisted of water lots, underlain with mud and very soft clays, to a depth varying from 60 ft. to 95 ft. On this site ship unloading bridges with supporting runways had to be built. These 675 ft. bridges span a stocking area which must sustain a unit loading of 4½ tons per sq. ft. The dock had to be capable of future progressive expansion without interference with everyday operation.

New Type of Dock

Estimates showed that the cost of the usual method of supporting this type of dock entirely on bearing piles capped with reinforced concrete was exorbitant. Stelco engineers in collaboration with eminent soils mechanics consultants conceived and built a radically new type of dock.[2] A trench was dredged along the face of the dock to firm clay, in places down to 95 ft. This trench was filled to above water level with the slag by-product of the blast furnaces. Sheet piling forming the dock bulkhead was then driven into the slag to a depth of 18 ft. below eventual channel level. The piling was then tied back to the reinforced concrete bridge runway adjacent to the dock face. This type of dock was built for 60% of the cost of the conventional bearing pile dock. The original 800 ft. dock has now been extended to 3000 ft. and will be further extended to its ultimate 4100 ft. length as required.

Since only one unloading bridge was to be installed in the first instance, it had to be reliable and carry as large a pay load as was practical. This was necessary to get rapid unloading of the ships to enable them to make as many trips as possible during the shipping season. The size of grab bucket was restricted by the width of the hatches of the Lake carriers. Even with this limitation the bridge can unload and stock 17 tons of ore per cycle, equivalent to a rate of 1100 tons an hr. For reliability it was variable voltage equipped throughout and all critical items were spared. In 1957 a second bridge was added after the dock was extended to 2500 ft. (Fig. 2 shows bridges and portion of dock.)

Fig. 2. View of two bridges unloading a boat and stocking. Construction of recent extension to bridge runway in the foreground. Sinter plant is at the left.

Conveyor System from Dock

In addition to unloading the boats the bridges must be capable of feeding ore or coal from the stockpile to conveying equipment for transfer to the blast furnaces and coke ovens respectively. As initially conceived, the new dock (No. 2) would start out by handling coal only, with all ore being handled through the old No. 1 Dock. Progressively, as the plant increased in size, ore would replace coal until all the ore would be carried on No. 2 Dock. Ex-stocking facilities had to be geared to this transition. Studies showed that when the new coke ovens, which were to be built to supply coke to the new blast furnace, came into operation in 1953 the old method of handling coal by railway cars from the stockpile to the coke oven storage bins would be inadequate. This was due principally to the difficulty in unloading the bottom dump hopper cars due to freezing in the winter. Various alternatives were studied with the cardinal points always in mind. These studies showed that from a reliability and handling cost standpoint a conveyor system from the new dock to the coke oven storage bins was the best arrangement. While the capital cost was high, it was more than offset by the reduced handling costs.

This system took the form of a collecting conveyor behind the landside bridge runway. The conveyor is fed by the bridges through a self-propelled hopper car, running on rails, and straddling the conveyor. Flexibility is provided since the belt can be loaded from the stockpile by conventional crawler derrick equipped with a grab bucket. This is necessary when the bridges are tied up for long periods unloading ships. A cross conveyor takes the discharge from the collecting belt to the coal blending storage bins. The collecting conveyor was designed so that it could be moved progressively as ore replaced coal on the dock. The conveying system was originally designed to carry 600 tons of coal per hr. to deliver a 24 hr. supply to the coke oven storage bins in a 16 hr. period. Provision was made for ultimately speeding up the system to carry 800 tons an hr. pending future construction of a new coal dock.

Fig. 3. View of new coal handling system just after completion. The travelling hopper is being loaded at the extreme right. Blending bins at right centre. Storage bin above coke ovens at left centre. Construction of new conveyor system to new oven bin at upper left.

Coke Ovens

The coal is converted to coke, which is suitable for the chemical reactions in the blast furnaces, in coke ovens. Once a coke oven is fired it must remain in continuous operation until it is dismantled. While a coke oven can be slowed down to a certain extent, it must never be allowed to cool because contraction would damage the fire-brick linings and a complete rebuild would be necessary. It is essential therefore, that the ovens be assured of a constant supply of coal. This is provided for in various ways. There are two sets of surge bins between the dock storage area and the ovens. The first set is located at the coke oven end of the main conveyor from the dock. In addition to providing storage these bins are used for blending the various grades of coal required to make good quality coke. The other storage bins are above the ovens themselves. They discharge by gravity into charging machines which feed the coal into the top of the ovens. These storage bin systems can maintain the ovens at full operation for 18 hrs. This surge ensures a steady flow to the ovens in the event of an interruption in the handling system, such as a conveyor breakdown.

Since 1947 one hundred and ninety-one new coke ovens have been built. Some of these replaced the original battery of ovens which operated continuously from 1918 to 1953. Fig. 3 shows the new coal handling system.

Sinter Plant

The sinter process deserves special mention since it has just come into its own in the last few years. Its impact has involved considerable changes to plant layout concepts and raw material handling systems. Briefly, sintering consists of placing a mixture of fine iron ores, flue dust, and coke fines for fuel, on a moving grate and igniting. Air is sucked through the moving bed until the mass fuses and becomes a porous clinker. Until recently the sinter plant was used as a scavenger, particularly as a means of utilizing the fine flue dust removed from the gas by-product of the blast furnaces. This dust contains as much as 45% iron. When mixed with fine ore and sintered it is in a form which is very palatable to the blast furnaces. Before the present trend to sinter and other ore benefication methods, ore as dug from the Mesabi range, coke and limestone lumps were fed into the top of the blast furnaces. The fines in the ore made the bed of materials in the shaft quite dense and iron production was limited due to the restricted amount of air that could be blown upwards through the bed, channelling of this air and poor contact of the ore, limestone flux and coke. Tests showed that as the percentage of sinter in the blast furnace burden was increased the more permeable the bed became and the less coke was required as a reducing agent. In addition it was easier to separate the pure iron from its oxides state in the sinter form compared with the iron ore form. Consequently for any given blast furnace the iron production increased as sinter replaced ore in the raw state.

However the benefits obtained from ordinary sinter have been far surpassed by the use of self-fluxing sinter which has been pioneered in Canada by Stelco, during the last two years. Self-fluxing sinter is made by adding limestone and dolomite fines to the ore and coke mix before it is fed to the sinter grate. This eliminates the necessity of adding the flux lumps at the top of the blast furnace. The fluxes are therefore intimately dispersed throughout the sinter and can do their job quicker and more thoroughly. Full scale tests on blast furnaces at Stelco have proven that iron production can be increased at least 60% by replacing all the raw iron ore in the charge with self-fluxing sinter.[3] At the same time the overall coke requirement per ton of iron produced decreases 20%. The impact on the industry can be seen when it is considered that this increase in iron production can be obtained at 65% of the cost of the equivalent blast furnace facilities utilizing raw ore.

Importance of Location

Now let us examine the effect of the sinter plant on the old concepts of material handling at Stelco. Before the advent of the sinter plant, ore was loaded from the dock stockpile by the unloading bridges into 60 ton bottom dump ore cars either at the front or the back of the dock; these cars were hauled up a grade to the top of the blast furnace storage bins. A multitude of bins had to be provided for the ultimate blending of the various ores. A better arrangement would have been to have the ore dock backing onto the blast furnace storage bins so the cars could be loaded directly at the high level. However, this was not possible at Stelco hence the long grade. Since the ores will now be diverted through the sinter plant it is now more important that the sinter strands be located adjacent to the ore storage facilities. A reliable facility for conveying the finished sinter to the blast furnaces is also a necessity. At present Stelco has only one sinter plant which went into operation in 1955. It supplies 30% of the iron bearing material to the blast furnaces. All ore to be sintered is at present hauled by truck from the No. 1 Dock and dumped into small capacity bins which feed the conveyor supplying the sinter plant. Flue dust, limestone and dolomite fines are handled in the same manner. Various types of ores used for blending in the sinter mix must be handled separately. In addition all the ores must be screened since only —⅜″ material is suitable for good sinter. Since the single belt feeding the sinter strand can only handle one type of material at any ore time, adequate storage bins are provided ahead of the sinter strand for each type of material. Proportioning rotating disc feeders at the bottom of each bin discharge onto a single collecting conveyor to provide the required mix. This is conveyed to the top of the sinter strand and fed onto the grate. Completed sinter drops from the end of the strand to a rising cooling conveyor. This discharges across streams and onto a conveyor which conveys the material to hopper cars. These cars are hauled to the blast furnace bins in a similar manner to the ore. Fig. 4 shows the sinter machine in operation.

Planning a 100% pre-prepared charge to the blast furnaces at Stelco is well underway. It is not proposed to go into this planning at this time. It should be pointed out, however, that sintering is becoming a vital link in the chain, so an assured sinter supply and adequate sinter handling and storage facilities must be provided to ensure continuous operation of the blast furnaces.

Fig. 4. View looking towards loading end of sinter strand. Conveyor elevating mixed material to head of strand at left.

Blast Furnaces

Stelco has 4 blast furnaces in a line, adjacent to, but at right angles to the ore dock and coke ovens. "D" Furnace, the latest and largest, was completed in December 1952 and is situated at the west end closest to the Coke Ovens and Ore Dock. While this location created critical construction problems it was felt that the ultimate ease of getting materials to this furnace would more than compensate. Blast furnaces are also operated continuously so a constant flow of materials to and from them must be assured.

Let us first consider the overall materials flow at the furnaces. Each furnace is provided with a number of elevated storage bins situated near its base. The number and size of bins depends first on the number of different materials to be charged to the furnaces, including separate bins for each type of ore required for different grades of iron; secondly on the amount of reserve capacity considered necessary to keep the furnaces in operation during any reasonable foreseeable disruption to the handling systems feeding the bins. Each material, with the exception of coke, is drawn from the bottom of the bins into a self-propelled weighing car which, in turn, dumps the load into one of two skip cars in the required proportions and sequence. The skip cars alternately hoist the material to the top of the furnace on a sharply inclined track ramp. They discharge into the top of the furnace through a revolving seal. The coke bins are located adjacent to and on either side of the skip pit so that they can discharge directly into the skips through their own weigh hoppers.

"D" furnace was built into this system while the other three furnaces were kept in operation. Since it was built between the existing three furnaces and their source and route of ore and coke it was no easy job. The various materials supplied to the existing furnace bins were delivered in bottom dump hopper cars. These operated on two tracks located on top of the bins and common to all furnaces. This elevated system commonly called the "highline" was fed by a single elevating track at either end. "D" furnace bins had to be built into this system immediately adjacent to an operating furnace without cutting off the supply of materials. In addition the top elevation of the bins was restricted to the level of the common over-running tracks. Since space limited the length and number of bins and also the width the only alternative was to make them deeper to provide sufficient storage. This meant that the scale car at the bottom of the bins had to be located in a trough considerably below the ground level on which the other scale cars operated. Extensive alterations had also to be carried out to the approach trestle used to carry the ore cars to the highline.

Run-Around Track

Fig. 5 showing "D" furnace under construction gives some idea of how the job was carried out. A third elevated track was built adjacent to the bins and outside the curve of the existing approach trestle. To assure stability during the subsequent excavations for the new bins and skip pit the portion paralleling the bins was seated on projecting piles driven 80 ft. into the ground to refusal. This run-around track was connected to the existing highline tracks well clear of the new construction. Admittedly there was a ramp access at the other end of the highline but this could not carry all the materials required for the other three furnaces for an extended period without disruption. Access to this east ramp was at the opposite end of the plant from the ore dock and involved a tortuous railway haul through the plant. Connections to the new runaround track at both ends were therefore made in short order working around the clock.

The supply of coke to the existing furnaces also had to be maintained. Coal is roasted for 16 hr. in the coke ovens and the red hot coke product is then pushed by a large ram into a self-propelled car. The car carries the coke under a quenching station where it is drenched and cooled with water. It is then side dumped onto a ramp where it is further air cooled and then fed onto a belt conveyor. When construction on "D" furnace started this single inclined conveyor discharged the coke into a screening station where the fines were removed. A further inclined conveyor carried the larger coke to a loading station above the highline from which the three operating furnaces were fed. Since this loading station was supported on a portion of the approach trestle which had to be removed it had to be temporarily supported by a bridge straddling the highline. This is shown to the left of Fig. 5. You can also see coke cars being loaded on the runaround trestle.

Studies showed that the existing coke handling system could not cope with the 65% increase represented by "D" furnace for the following reasons:

1. The single conveyor system would be overloaded and was a serious threat to operations at the blast furnaces;

2. The existing coke screening station would also be overloaded giving poor screening and susceptibility to frequent breakdowns;

3. Since coke is a lightweight bulky material, rail traffic on the highline would become so congested it would be almost impossible to maintain the required flow to all the storage bins.

Additions Necessitated

In view of the first point it was decided to put a second conveying system from the new coke ovens, then under construction, to the highline. The second point was dealt with by the installation of a second primary screening station. To obviate congestion on the highline it was decided to convey the oversize coke from either screening station directly to "D" furnace coke bins by conveyor. In an emergency, however, "D" furnace coke bins can be charged by rail cars from the new car loading station servicing the remaining furnaces, and located on the new approach trestle.

Limestone lumps are delivered by rail from the company's quarries in Beachville in bottom dump cars. Storage tracks adjacent to the east approach trestle provide a surge for emergency. Various ores and sinter are still delivered from the two storage docks and the sinter plant to the Blast Furnace bins over the access ramp from the docks.

In 1957 planning for a fifth furnace, "E", at the east end of the highline was well underway when the welcome advantages of self-fluxing sinter appeared on the scene. Studies had shown that deliveries of material by bottom dump hopper cars to the five furnaces would be impractical. The additional congestion on the highline would have meant delays due to the inability to get material to some of the bins before they were empty. Deepening the bins on the original three furnaces while physically possible would have been far too costly. In addition it would have meant protracted shutdowns of the furnaces with consequent loss of much needed iron production. It had therefore been decided that a new conveying system running the entire length of the highline to the new furnace from the new dock would have to be provided. As engineering for this elevated and costly conveying system was about to start the advantages of self-fluxing sinter began to make themselves felt. Engineering for the new furnace was held up and it soon became apparent that self-fluxing sinter from the existing sinter plant would increase iron production from the existing four furnaces an amount equal to half the anticipated production from the new large "E" furnace. This increase in production meant that "E" furnace could be delayed for a few years. It also indicated that a further increase in iron production could be obtained by the addition of a second sinter plant with a substantial capital saving over "E" furnace. At present planning for the second sinter strand is well underway.

Another apparent advantage of self-fluxing sinter is the simplification of materials handling to the blast furnaces, especially when the stage of 100% pre-prepared burden is reached. At that stage only one iron bearing material, sinter, need be delivered to the blast furnace bins, instead of the multitude of different grades of ore previously required for blending at the furnaces. In addition this sinter will also contain the limestone and dolomite flux material which previously also had to be delivered separately in lump form, to the highline. The amount of coke required at each furnace will, however, increase. Although the amount of coke required per ton of iron produced will substantially decrease, the increase in iron production will more than compensate. So we can look forward to only three materials being required for charging to the blast furnaces, sinter, iron concentrate pellets, and coke. Congestion will be further relieved due to the fact that the sinter can be dumped in any one of the bins which were previously designed for a specific grade of ore.

Consideration is being given to delivering all the sinter from the sinter plant to a loading station on the highline by belt conveyor. This would necessitate adequate cooling of the sinter after it was discharged from the sinter strand. Against this we must balance the possible saving in heat by delivering the sinter to the furnaces while it is still hot. This, of course, would mean delivery in insulated hopper cars and the blast furnace bins would also have to be protected.

The congestion problem unfortunately now moves from the furnaces back to the sinter plant. Large separate bins must be provided between the ore stockyard and the sinter strand for each grade of ore required for blending in the sinter mix. In addition, bins will have to be provided for limestone and dolomite fines, coke fuel fines and the iron scale which is a by-product of the rolling mills. But the lessons we have learned in materials handling to the blast furnaces are now standing us in good stead in planning for materials handling to the sinter plants.

Conveyance of Molten Iron and Slag

Now that the materials are flowing into the blast furnaces we must get the products of the furnaces to their destination. With the exception of the gas piped from the furnaces, these are two, molten iron and slag. Slag is made up of the flux materials and the impurities from the original ore charge. In a molten state it floats on top of the molten iron in the bottom of the furnace. It is drained off into pits adjacent to the furnace, frequently. There it is water cooled, loaded by electric shovel, into large dump trucks for transportation to its destination. Blast furnace slag has many practical uses and the greater part of it is delivered from Hamilton Works to an outside processing plant. Each furnace has two slag pits for continuity. While one is being filled, the other is being dug out. Originally slag was drained into pots which were transported over the same tracks as the hot metal and dumped along the shore. A comparative study proved the present system to be much cheaper to operate. In addition congestion was relieved on the important hot metal runs; an important consideration.

Iron is drained off at a level below that of the molten slag. It flows by gravity to fire brick lined rail containers which deliver it to the open hearths. Vessels carrying 70 tons provide this service from the two smaller furnaces and on their arrival at No. 2 Open Hearth shop the iron is poured into an 800 ton mixing storage ladle. Iron from "C" and "D" is conveyed in 200 ton torpedo shaped ladles which also act as storage capacity.

Any disruption of the flow of iron from the blast furnaces to the open hearths could seriously impair open hearth operation especially since very little surge, in the form of stored liquid iron, can be provided. To date rail haul is the only means of transportation. To meet materials handling requirements therefore it is essential that this main track system be reliable and that an alternative route be provided where possible. In addition the haulage of other materials over the main hot metal track should be kept to an absolute minimum to obviate interference. The installation of "D" blast furnace required a rearrangement of the main hot metal tracks and a much heavier 130 lb. rail to take care of the increased wheel loads imposed by the 200 ton ladles. These changes were carried out step by step without disruption of the hot metal flow from the existing three furnaces. It required a great deal of planning and layout work including a separate drawing for each step to avoid confusion.

Open Hearths

The next link in the process is the open hearth furnaces. While steel is made in batches in individual furnaces, the operation of a battery of furnaces (a shop) can be considered a continuous 24 hr. operation. The first step in steel-making is the melting of scrap by intense heat in a covered bath shaped vessel. Hot iron is then added. The proportion of these two main ingredients varies depending on a number of conditions but equal proportions is a good average figure for our purposes. Various other elements are added, principally lime and high quality ore or sinter for heat control and purification purposes. The impurities collect in the slag formed on top of the steel in a similar manner to the blast furnaces. High heat is maintained within the furnace during the process, which takes about eight hours. When refining is complete steel is drawn off through a tapping hole and flows by gravity into a brick lined ladle. Any slag not drawn off previously collects on the top of this ladle and overflows into a second slag ladle.

Construction of Stelco's No. 3 Open Hearth shop paralleled that of "D" Blast Furnace and it came into operation one day before that unit. It consists of four furnaces rated initially at 275 tons each but now producing 315 tons per heat. A fifth furnace is now being added with a nominal capacity of 400 tons but provision is being made in the handling equipment for potential 500 ton heats from this furnace.

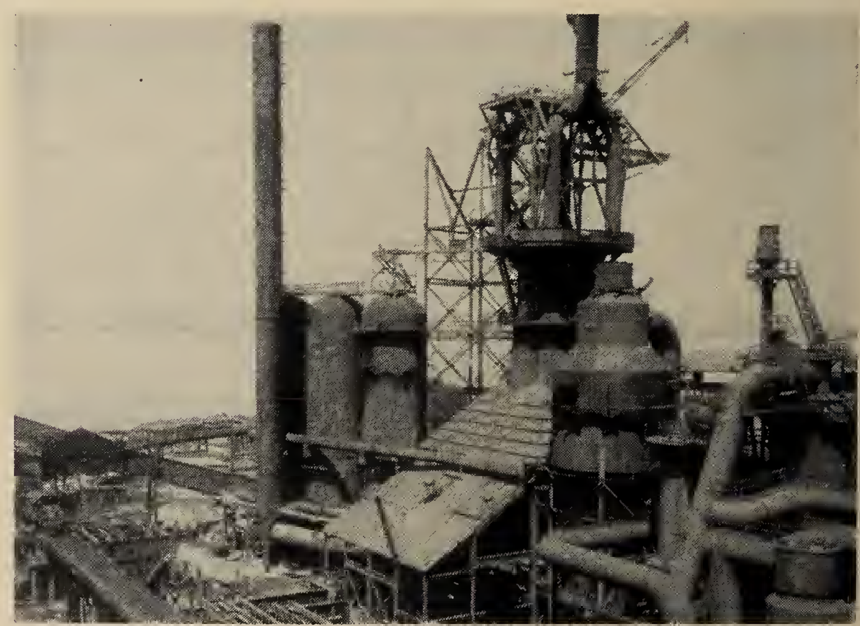
Non-interference of Flow To and From

Materials handling to and from No. 3 Shop dictated the layout. While the shop itself was located more or less on virgin ground the material flow had to be correlated with existing equipment. The first two principles of materials handling can be expanded to include a sub-rule stating that "the flow of materials to a unit should not interfere with the flow of materials away from that unit or with the material flow to and from any other unit". While this applies to all steps in the process it is particularly applicable to the open hearths. With this in mind No. 3 shop was arranged so that hot metal and scrap approach from the west while ingot and returning empty mould tracks extend to the east of the shop. In addition the hot metal track delivers to the ultimate centre of the shop, outside and to the south of the building, on ground level. Scrap is delivered into the south bay of the building but at an elevated level. The ingot and mould tracks are on the north side of the shop. Many layouts were studied before the ultimate one was adopted as the best from a materials handling standpoint. Figure 6 is a plan of the shop including the new furnace under construction. Figure 7 is a cross section. Reference to these two illustrations will aid in following the materials flow description.

Ladling Procedure

The 200 ton hot metal ladles are spotted on the south track at ground level. By rotation they pour into the ladles used to charge the furnaces. While these ladles are being filled they rest in a winch-driven transfer car situated below ground level on a weigh scale. It is essential that all

Fig. 5. "D" blast furnace under construction.



materials going into each batch of steel be accurately weighed both from a quality standpoint and a knowledge of the true weight of the batch of finished steel. The loaded ladle is then transferred to a point underneath the charging aisle. It is lifted through a hatch in the charging floor by 150 ton cranes which carry it and charge the iron into the scheduled furnace.

Scrap Boxes

Scrap handling and charging facilities are the chief bottleneck in restricting the output of Open Hearth furnaces. With this prior knowledge very careful consideration was given to scrap facilities in designing No. 3 shop. Scrap is charged into the furnaces in steel rectangular containers. These containers are delivered on flat buggies to a point immediately in front of the furnaces. An electric charging machine picks up each box in turn, on a ram, inserts it through a door into the furnace, then empties it by rotation. Naturally the larger the box the faster the furnace can be charged but the box size is restricted to the door opening and the lifting capacity of the charging machine.

When Stelco's older No. 2 shop was built it employed scrap handling facilities utilized throughout the industry at that time. This consisted of loading the buggies in a scrap yard at ground level and hauling them up a ramp to the charging floor level. Since the capacity of each buggy was limited a great deal of rail traffic was involved with frequent derailments of the small scrap cars principally due to scrap falling from the buggies. No. 3 shop was planned to cut down on the traffic and the frequency of derailments. For this shop, scrap is elevated by a highline ramp, in large capacity gondola cars, into a bay adjacent to the charging aisle. In this bay the boxes, resting on their buggies, are filled from the gondola cars by fast electric overhead magnet cranes. The scrap buggies therefore always operate at the charging floor level. As each train of buggies is loaded it is weighed and then located on storage tracks, from where it can be rapidly located in front of the furnace to be charged.

Efficiency Increase

Even in the short period from 1952 to the present the increase in operating efficiency has greatly reduced the time required to make a batch of steel. Even shorter times are anticipated in the very near future by the use of oxygen jetting through the roof. This means more material must be handled in a given time and it had a major influence in the planning for the new furnace. The footage of scrap loading and holding tracks per furnace has been substantially increased and the door left open for a further increase in the future.

The other large tonnage items used in the open hearths are ore, sinter, lump lime and dolomite. In other modern shops these materials are usually fed from ground hoppers, by inclined conveyors, to large storage bins above the scrap loading bay. It was felt that this was not satisfactory for our new shop for two reasons: first, it added to the congestion at the scrap loading level and secondly we anticipated that the gravity flow from these bins would be disrupted by freezing of the material in the bins. Accordingly it was decided to install a separate building for this material. This is indicated as the miscellaneous material building in Fig. 6 and 7. Material is fed into the open bins by bottom dump hopper cars operating on the high level track system. It is then transferred to the boxes on the charging buggies by means of an electric overhead crane equipped with a grab bucket. In addition, lime lumps can be delivered from our own lime kilns by large trucks which tip directly into the lime bin.

It should be mentioned that alloying and quality control elements in minor quantities are added throughout the open hearth process. While a great deal of care was required in planning the handling facilities of these materials, they will not be described in detail.

Handling of Slag

During the refining process slag is drawn off through the front charging doors and into a slag pot suspended on a transfer car below the furnace. This car moves the pot to the discharge side of the furnace (the pouring aisle). The slag pot is then transferred by the overhead cranes to a two pot slag car. The overflow slag from the steel ladle, mentioned above, is also transferred to the slag pot car. When the slag has set it is hauled by rail and tipped by specially adapted crawler derricks into a long slag pit. It is then water cooled, broken up, and magnetically processed to recover entrained steel.

Each completed batch of steel is tapped into a single ladle in the pouring bay. The loaded ladle is immediately lifted by heavy cranes for transfer to the pouring station. Cranes for the present four furnaces have a rated lifting capacity of 350 tons. A new crane to service the larger furnace will be capable of a 625 ton lift.

Design Problem

An interesting design problem was encountered in the large crane runway girders spanning the furnaces and sustaining the very heavy crane wheel loads. The span over the present furnaces is 112 ft. and the plate girders are nearly 12 ft. deep and weigh 125 tons. They were the largest plate girders ever manufactured and erected in Canada. The spans for the extension of the shop for the larger furnace are 130 ft. long and the new crane lift is much heavier. Since the crane runway rail level must be constant throughout the shop and the clearance over the furnaces is limited the new girders were restricted in depth. In addition it was desirable that the new crane be able to operate over the existing crane runway to service the older furnaces. The problem was solved by the use of low alloy high strength steels. The weight of the 130 ft. girders has been cut from a potential 300 tons with conventional structural steel to 200 tons. The wheel loadings of the new crane have been matched to those of the older cranes also by the use of high strength steels.

Steel is poured through a hole in the bottom of the ladle into a line of prepared ingot moulds sitting on flat ingot cars. This is done by the crane inching the ladle successively over each mould. A stopper mechanism actuated by a man on a platform shuts off the flow as the ladle is moved from above one mould to the next.

The next steps in handling the ingots are critical. The steel must have time to set in the ingot form but it is also important to get the stripped ingots into the reheating pits (soaking pits) as soon as possible to conserve heat. Steel men talking about "track time" are almost certainly referring to the time lapse between pouring the steel into molds at the open hearth and getting the ingots into the soaking pits. Any delay in this procedure over the minimum permits the ingots to set will materially affect their costs. The layout of the track system from the open hearth through the stripper building and to the soaking pits is very important. There must be no interference between the flow of ingots to the soaking pits and the return flow of empty ingot moulds to the mould preparation shop and subsequently back into the pouring aisle for recharging. At Stelco we not only had to consider that two open hearth shops would be discharging onto this track system, but allowances had to be made for an ultimate third shop. In addition, allowance had to be made for frequent surges due to furnaces pouring in rapid succession. To make matters worse, track changes to integrate No. 3 Shop into the system had to be carried out without interrupting the flow of ingots and empty moulds from, and to, No. 2 Shop.

A new mould stripper building was required with No. 3 Shop and provision also had to be made for an anticipated second ingot rolling mill with accompanying soaking pits. The problem was further complicated by track curvature restrictions and the difference in levels between No. 3 shop, No. 2 shop, the existing rolling mill and the planned second rolling mill. Various track layouts were made and studied by means of time flow charts. By this means the ultimate track layout slowly evolved. The smooth operation of the present track system justified all the comparative studies that were made.

New Stripper Building

In the stripper building the moulds are removed from the ingots or, in some cases, loosened for the subsequent removal of the moulds at the ingot soaking pits. This building must be conveniently located on the flow track between the open hearths and the soaking pits. Until No. 3 Open Hearth shop was built all stripping was done in a building located at the end of the soaking pits servicing No. 1 Bloom Mill. The original No. 1 mill and No. 2 Open Hearth Shop were located at right angles to each other. As the plant grew the two buildings were sucessively extended and converged at the base of an "L". This created a serious track bottleneck and it was apparent that no further extension of either building was possible.

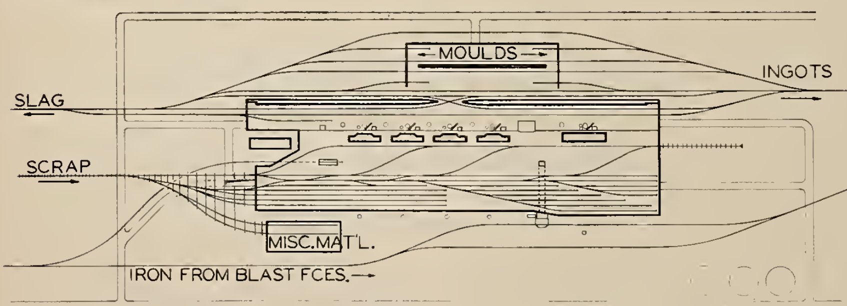
Second Blooming Mill

With the advent of No. 3 Open Hearth a larger stripper building was required. In addition a second blooming mill was in the offing since No. 1 mill was very near its maximum capacity and any serious breakdown could shut down all subsequent operations. A new stripper building was a necessity and its location to service the ultimate two blooming mills was extremely important. It was finally located on the extended line of No. 3 Open Hearth shop which forms the stem of a T between the two blooming mills. However, it was located far enough away from No. 3 shop to allow ample extension of that shop in the future. It was constructed straddling the new track system and equipped with a new 400 ton stripper crane. On completion the new track system was tied in to the old system and the new stripper building took over the full load. The 200 ton stripper crane from the original stripper building was modified and moved into the new building. The old stripper building was then dismantled permitting a better track arrangement at the former bottleneck. A stripper crane's capacity is rated by the pull it can exert on an ingot while holding down the mould; in other words the separating pull. Conversely it can hold down the ingot and pull up the mould. While the new crane is rated at 400 tons, it can momentarily exert a 1200 ton separating force. The location of the stripper building imposed additional restrictions on the track layout. Allowance had to be made for extension of the stripper building in the future and in addition the portion of the track straddled by the stripper and extending a reasonable distance from each end had to be level. This was necessary to prevent runaways of strings of ingot buggies.

Separation of Materials

We have now reached a point where our main stream of materials in process splits into two streams. One flows through the No. 1 blooming mill and secondary rolling mills, to be formed into bars and bar products. The other passes through the new bloom-slabbing mill, where it is rolled into slabs, and then through secondary mills where it is formed into flat rolled products.

Fig. 6. Plan of No. 3 open hearth shop showing larger fifth furnace now under construction. Note separation of track systems for different materials and extent of scrap tracks.



This paper has traced the handling of the main raw materials required to produce a finished steel ingot. However there are large amounts of secondary items without which a steel plant could not operate. The following figures will give some indication of what is involved in the use of these items at the present level of operations at Hamilton Works.

Water: 130,000 g.p.m. pumped from the bay and distributed throughout the plant. This is three times the quantity pumped by the City of Hamilton.

Blast Furnace Gas: 275,000 c.f.m. generated, by the blast furnaces, cleaned and distributed for use as fuel.

Coke Oven Gas: 30,000 c.f.m. generated by the coke ovens, purified and distributed for use as fuel.

Fuel Oil: 9,000 gal per hr. used in various furnaces throughout the plant. This would heat 20,000 homes.

Electricity: 1,300,000 kwh. per day is used throughout the plant.

FUTURE GROWTH PLANNING

One other important function of the steel plant engineer deserves special mention and that is his part in future planning. The words "his part in" were chosen specifically because future planning is a cooperative effort involving all divisions of the company. At Stelco it is the Engineering Department's job to correlate this planning under the guidance of top management.

The objective of future planning is to ensure a balanced logical company growth to meet the increasing steel demands of a growing Canada. It considers not only physical growth but financial. As a basis for planning some predictions of the future demand for steel must be made. The main factors influencing these predictions are:—

1. the trend of increasing population;

2. the greater use of steel per capita with the rising standard of living;

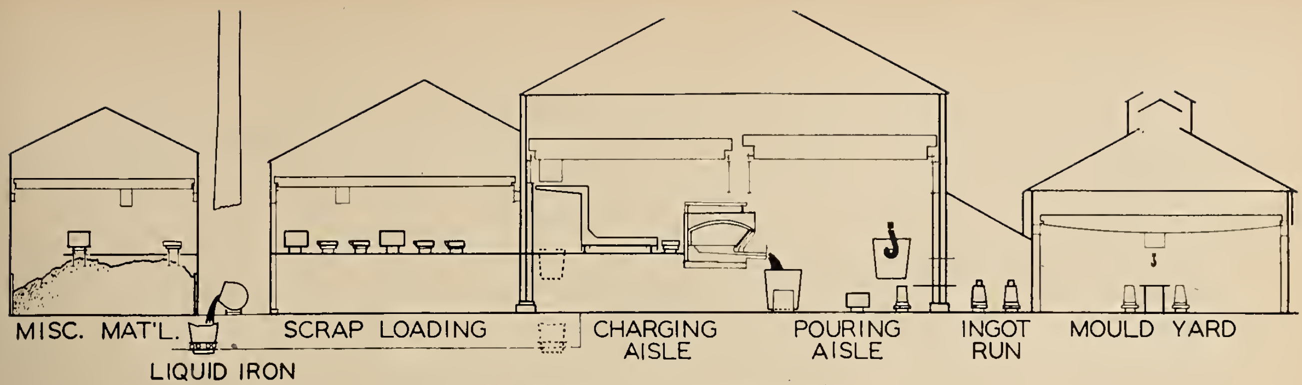


Fig. 7. Section through No. 3 open hearth shop.

3. the rapid industrialization of the country as Canada takes over the job of manufacturing more and more goods.

All these were considered in compiling Stelco's submission to the Gordon report and make a solid basis for future planning.

Planning Ahead

A logical question is "How far ahead do you plan?" Unfortunately there is no stock answer. A great many things will influence the decision, e.g. type of industry, frequency of radical changes in any particular industry and the magnitude and rapidity of trends in the country as a whole. Broad planning at Stelco covers about 20 years. In addition there is short term planning, which can be discussed in more detail.

Since the sales predictions take all the above factors into consideration they are the logical starting point for future planning. Through market research sales demand charts covering a twenty-year period are made up. Initially these cover broad categories for which steel must be provided, e.g. tin plate,, hot and cold rolled sheets and bars.

The Engineering Department, working with the operating division, then establishes what is required in the way of physical plant and when each unit is required to meet the sales demand forecasts. Starting with these forecasts, demands at each step in the process are traced right back to basic ore and coal. Curves are plotted showing yearly tonnage requirements for the future. On these, the timing of each unit can be indicated.

Flexibility of Plant Layout

The next step is plant layout incorporating the required units. In some cases alternative locations or processes, at different stages, require comparative economic studies. If these are not conclusive, due possibly to further development work being required, plant layout must be left flexible. Generally, however, once the individual units of physical plant are established layout can be advanced. While many factors influence the layout probably the most important are:

1. The size and shape of the property available for expansion of a given works;

2. A layout which reduces handling costs to a minimum by providing a smooth continuous flow from raw materials to the shipping of finished products. Materials handling will essentially govern the layout; and

3. The ultimate capacity of some of the major units as they affect the balanced production of other units, e.g. it may be possible to lay down a new slabbing mill which could produce 3 million tons of slabs per year but the huge capital investment involved would not be justified unless other units in the process could be extended to handle this additional tonnage.

Future Capital Requirement Schedule

When the physical layout has been established estimates of the cost of the new units are prepared. These are then incorporated into a future capital requirement schedule which is submitted for management's use.

The comparative economic studies mentioned above become more frequent in short range planning. They are usually correlated in the form of a report prepared by the engineering dept. but incorporating the work of many other departments. The metallurgical department studies the feasibility of comparative processes, particularly from a quality standpoint. The operating division work out unit capacities, surge requirements etc. to ensure that the new unit can be incorporated into their operations in the most efficient manner. Industrial engineering in collaboration with accounting estimate operating costs. Finally the accounting division combine operating costs, inventory costs, working capital and capital estimates to give a return on investment. This is generally the common denominator upon which management bases its decisions.

Importance of Review

In these days of rapid development and changing conditions it is necessary to review long term forecasts frequently. The main theme in planning is to have your course charted ahead so that when decisions have to be made there is a sound foundation on which to base them. At times a large portion of planning work may have to be discarded due to some unforeseen new development. This, however, does not mean that no benefit has accrued from the work. One of the principal benefits is the personal development of the engineer. He learns to look ahead and keep an open mind. His vision is widened and he develops a sense of proportion. Planning teaches him the value of teamwork and co-operation. It gives him an appreciation of the importance of the work of others in the overall pattern. He realizes that while his technical contribution is important, unless it is integrated with other functions there can be no assured progress.

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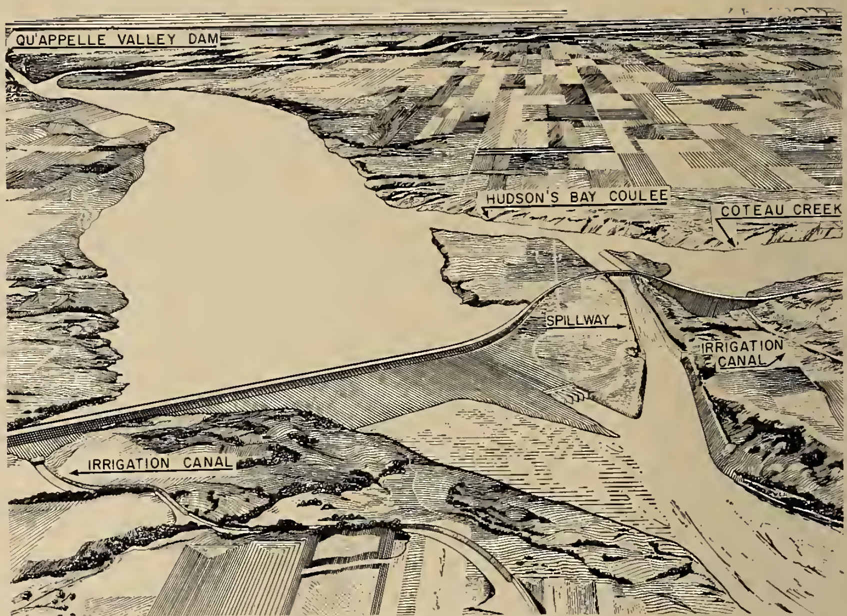
THE SOUTH SASKATCHEWAN RIVER DAM



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The South Saskatchewan River dam is the principal structure in a large multiple purpose project in central Saskatchewan. When completed the project will irrigate an area of approximately 500,000 acres in a region which has experienced severe losses from drought conditions and it will stabilize agriculture in an area several times as large. It will make possible the construction of a large hydroelectric power development in an area where hydro-electric power possibilities are otherwise very limited. It will furnish unlimited water supply for urban centres in Southern Saskatchewan which have no other visible source. It will provide flood control to all areas along a 400 mile reach of the South Saskatchewan River and create valuable recreational facilities within reasonable access for a larger portion of the population of Saskatchewan.

THE DREAM of damming the South Saskatchewan River has persisted in one form or another for 100 years. In 1857 the British Government sent an expedition under Captain Palliser to explore Western Canada. In 1858 the Government of Canada sent an expedition under Professor H. Y. Hind of Trinity College to explore the Assiniboine and Saskatchewan River valleys. Both of these explorers noted the close interrelationship existing between the valley of the South Saskatchewan and the Qu'Appelle lake and river system.

Palliser's observations concerning the interrelationship of the two valleys led him to suggest the feasibility of a water-communication system connecting the two. Hind went on to suggest the construction of a dam across the South Saskatchewan to divert its waters down the Qu'Appelle valley. He said that "the construction of a dam 85 ft. high and 800 yd. long would send the waters of the South Branch down the Qu'Appelle and Assiniboine into the Red River, thence past Fort Garry into Lake Winnipeg". He went on to say: "The time may yet arrive when the future population of Ruperts Land and the Dakotah territory will find it advantageous to construct these or similar works, even if they should be for the purposes of irrigation or inland navigation."

In 1919 the late Wm. Pearce, eminent engineer and land surveyor, pointed out the possibility of the diversion of water from the North Saskatchewan, the Clearwater and the Red Deer rivers to supply water for agricultural uses throughout the central plains of Alberta and Saskatchewan. This led to an extensive survey by the Reclamation Branch of the Department of Interior in 1920, which survey revealed two large tracts of land which could be irrigated from the sources suggested by Mr. Pearce, one in the Youngstown-Hanna area in Alberta and the other in the Rosetown-Outlook-Saskatoon area in Saskatchewan. The conclusion was that it was feasible. However, it would have been very costly. In 1930 the Federal Government, by agreement, transferred the natural resources to the Provinces and no further action was taken.

In 1939 the Prairie Farm Rehabilitation Administration of the Federal Department of Agriculture (P.F.R.A.) began detailed surveys of the William Pearce proposal. These were directed particularly towards the irrigation of areas in Alberta with possible extension into Western Saskatchewan. Some of the soils were found difficult to irrigate and the route into Saskatchewan presented major difficulties. A modification of the project, directed principally towards stockwatering, is now under active consideration.

In 1943, the P.F.R.A. began investigations of a modification of the Pearce proposal with the object of irrigating the lands in Saskatchewan by diversion of the South Saskatchewan River in Saskatchewan. The advantages seen were as follows:

(1) It would enable the Province of Saskatchewan to proceed with irrigation independently of another Province;

(2) It would bring the point of diversion closer to the irrigable lands in Saskatchewan, thus saving large water losses in transportation and maintenance costs on the long canals from Alberta;

(3) The dam required for diversion of water for irrigation on the South Saskatchewan would provide head for the development of hydroelectric power;

(4) The source of the water would be entirely within the basin of the South Saskatchewan and would not involve the diversion and use of water from the North Saskatchewan basin as would be required in the Wm. Pearce scheme.

The first alternative for a diversion in Saskatchewan involved a study of six possible damsites in the Cabri area north of Swift Current. There was some reason to believe that foundation conditions in this area would be better than was revealed by information on hand along other sections of the river where great depths of sand were indicated. Furthermore, it would be possible to divert water through a natural depression to the Elrose-Outlook-Saskatoon area by a dam about 130 ft. high. However, the borings in the Cabri area indicated that foundations were no better than elsewhere along the river and that the only feasible type of dam would be an earth embankment. Concurrent surveys indicated that a large area of good agricultural land would be flooded by the reservoir and that a large portion of the irrigable tract in the Rosetown-Elrose area contained heavy soils not suitable for and which did not require irrigation. It was also revealed that there were large areas of land suitable for irrigation on the east side of the river, north and east of Outlook, which could not easily be commanded from the Cabri diversion.

Attention was then directed to the Elbow-Outlook stretch of the river where a higher dam with a much larger reservoir would be possible and from which water could be delivered to the most desirable portions of the Rosetown-Outlook area as well as to the area east of Outlook. From it, also, water could be diverted down the Qu'Appelle River for irrigation in the Qu'Appelle valley and for the maintenance of lake levels, and for urban water supplies, including the cities of Regina and Moose Jaw. The potential power development would be greater than at the Cabri site and it would be closer to the load centre. The recreational facilities provided by the project would be within easy reach of the larger Saskatchewan cities.

Studies of several sites in the Elbow-Outlook area were carried out. The one finally selected is midway between Elbow and Outlook where Coteau Creek flows into the river from the west. Here the topography is ideal for the construction of the separate spillway required for an earth dam and there is an abundance of the various types of material required for a zoned earth fill. There is ample pervious material at hand as well as large quantities of concrete aggregate on the site. An engineering report on the feasibility of the dam was filed in 1947. The drainage basin and the sites referred to are shown on Fig. 1.

Agreement

This was the first multiple purpose project that had been proposed in Western Canada and so it was natural that extended negotiations between the governments were required before action, if any, could be taken that would lead to its realization. The negotiations were completed on July 25, 1958, when the Governments of Canada and Saskatchewan signed an agreement to proceed with the project and agreed to share in the cost.

The agreement provides that Canada will construct the reservoir by constructing the main dam on the South Saskatchewan River and a subsidiary dam in the Qu'Appelle valley and such related works as are necessary to complete the construction of the reservoir. It provides that Canada and Saskatchewan will share in the cost of constructing the reservoir, 75% thereof to be borne by Canada and 25% to be borne by Saskatchewan, provided that Saskatchewan's share of this cost shall not exceed $25 million. Upon completion, Canada is to transfer the reservoir and its related works to Saskatchewan but Canada is to maintain the works for a period of ten years and shall be responsible for the cost of such maintenance for a period of six years; during the remaining four years the cost is to be shared equally.

The agreement also provides that, if Saskatchewan proceeds with the construction of hydroelectric power facilities, the cost of these is to be borne by Saskatchewan provided that Canada will contribute 25% of the cost of constructing and installing such penstocks as may be necessary to produce, at minimum operating head, 200,000 hp.

The agreement also provides that Saskatchewan will assume full responsibility for and undertake the construction, operation and maintenance of all the irrigation works required for the conveyance and distribution of water to all lands to be irrigated by the reservoir.

The South Saskatchewan River

As a background to the understanding of factors which dictate features of the design and which will dictate construction procedure, a knowledge of the characteristics of the river is necessary. The South Saskatchewan River is a mountain-fed stream. Its source is its many tributaries rising on the eastern slopes of the Rocky Mountains. The principal tributaries are the St. Mary, the Belly and the Waterton Rivers which are international streams and which rise in the Glacier National Park in Montana, and the Old Man, the Bow and the Red Deer Rivers which rise in Alberta. The drainage basin is shown on Fig 1.

Being mountain-fed, the river has two normal high stages. The first occurs at the time of snow melt in the foothills and on the plains, normally about mid-April. The second stage, which is usually the larger, results from snow melt in the mountains and usually occurs about mid-June. Records of the flow have been kept since 1911. The flow at Saskatoon, where continuous records have been maintained, has ranged from a minimum of 502 c.f.s. on December 12, 1936, to a maximum of 147,500 c.f.s. on June 15, 1953. There is a similar wide variation in the total annual flow. It has varied from a low of 3,440,000 acre feet in 1947 to a maximum of 14,600,000 in 1916. The average is about 7 million acre feet. A typical annual hydrograph is shown in Fig. 2. It is this wide variation in flow which requires a reservoir of the maximum capacity available in order to make the greatest possible use of all the water available.

Fig. 3 shows the annual natural flows, during the period of record, of the South Saskatchewan River at Saskatoon and the Saskatchewan River at The Pas, Manitoba. It also shows the depletion of the flow to meet the ultimate demands of upstream uses and the requirements of the South Saskatchewan River Project.

The Reservoir

The dam will create a reservoir 185 ft. deep at the damsite and extending for a distance of 140 miles up the main valley of the South Saskatchewan River to a point northwest of Swift Current and eastward in the valley of the Qu'Appelle River about 12 miles. It will have a total area of 109,600 acres, of which only 5,700 acres is cultivated land. The total capacity of the reservoir will be 8 million acre feet and, assuming a 40 ft. usable range, the live storage capacity will be 2,750,000 acre feet.

The full supply level of the reservoir will be higher than the summit in the Qu'Appelle valley between the South Saskatchewan River and the Qu'Appelle River. Hence an earth dam 90 ft. high will be required across the Qu'Appelle valley to contain the reservoir and to control the flow down the Qu'Appelle River. This structure, known as the Qu'Appelle Valley dam, will be 9,000 ft. long on the crest and will contain approximately 7,500,000 cu. yd.

To determine the effect of river sediment on the life of the reservoir, a silt determination program was begun in 1947 and has been carried out almost continuously until the present time. Depth integrating silt samplers were used to obtain the samples and bottom withdrawal tubes were used for the laboratory analysis. The conclusion arrived at from this program is that silting will not affect the useful life of the reservoir.

The Canadian Pacific Railroad line between Moose Jaw and Macklin at present crosses the Qu'Appelle valley in the reservoir area. It is proposed to revise this line to cross the valley on the Qu'Appelle Valley dam.

Fig. 1. Drainage Basin of the South Saskatchewan River

The Canadian National Railway line between Central Butte and Dunblane presently crosses the South Saskatchewan River on a low level bridge near Elbow. This line will be inundated and have to be removed. Its relocation is under study and final location has not been determined.

Several provincial highways will have to be relocated and the provincial highway bridge over the South Saskatchewan River north of Swift Current will have to be raised.

The reservoir is shown on Fig. 4.

Irrigation

Based on completed topographic and soil surveys, it is estimated that approximately 500,000 acres can be irrigated from this reservoir. The area is shown on Fig. 4. Of this area, approximately 40% can be irrigated by gravity from the reservoir and the balance will require pumping. Of the area that can be served by pumping approximately one-half will have a lift of 30 ft. or less and the other half will have varying lifts of up to 120 ft.

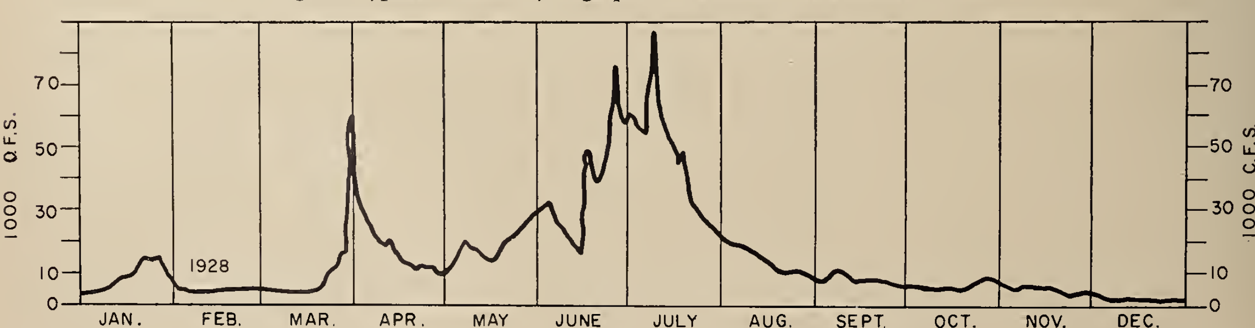
Power for pumping would be available from the generating station at the dam. Since the irrigation is the responsibility of the Province of Saskatchewan, the final area to be irrigated and the selection of the areas will also be its responsibility.

Power

The Province of Saskatchewan, through the Saskatchewan Power Corporation, will construct and operate the power facilities. At the present time the generating facilities of the Saskatchewan Power Corporation are composed almost entirely of thermal plants and there is no hydro plant in the system. Because there is no hydro plant in the system and because of the flow regulation available from the large reservoir, the hydro plant at this project will likely be used extensively for meeting peak demands. This will dictate the ultimate installed capacity.

After the river basin has been fully developed by upstream users for irrigation, domestic, industrial and power purposes, it is estimated that sufficient water will be available to produce 475 million kwh. annually.

Fig. 2. Typical Annual Hydrograph of the South Saskatchewan River



The wide variation of seasonal flow of this river has made power developments without large storage facilities impractical. The reservoir created by this project will provide almost complete regulation of the river flows and will increase the power potential of downstream sites, where storage cannot be provided at the plant.

Urban Water Supply

The creation of the reservoir will make it possible to provide a controlled flow of water down the Qu'Appelle valley. This will maintain lake levels in the Qu'Appelle valley and provide fresh flows down the Assiniboine River to Brandon and Winnipeg. The cities of Regina and Moose Jaw now pump water from one of these lakes and the project will guarantee and make possible the enlargement of this supply. The reservoir and associated canals will provide a water supply for towns and villages and for domestic and stock water supply throughout the area.

Description of Dam Site

The river valley at the site is about 225 ft. in depth and approximately 2,000 ft. in width at water level and nearly two miles wide at the top. During low flows the stream is much narrower and tends to meander between sand bars. The valley slopes are, in general, about 10:1; they vary from 6:1 to 14:1. Immediately downstream from the proposed fill, Coteau Creek flows into the river from the west. There is a low point between the river and Coteau Creek about two miles upstream from their junction. This is known as Hudson's Bay Coulee. Enclosed in a triangular area between Hudson's Bay Coulee, Coteau Creek and the River is a flat, plateau-like area. This makes it possible to utilize Hudson's Bay Coulee and Coteau Creek valley for location of a remote spillway and, at the same time, to locate the earth embankment in a two-mile stretch of river between Hudson's Bay Coulee and Coteau Creek.

The river bed at the site is underlain by up to 100 ft. of alluvial material consisting mainly of fine to medium sand located in a trough-like depression as shown on embankment centerline profile, Fig. 6. It is believed that at one time the river flowed at the bottom of this trough and has agraded to the present level. The sand is in a medium density state and pumping tests have indicated a permeability of 0.1 f.p.m. Undisturbed sand samples have shown some variations and stratification but, on the whole, the deposit is quite uniform.

The abutments are covered with a variable depth of overburden. Both the abutments and the river bed are underlain by bearpaw shale. This is a soft clay shale of Upper Cretaceous age. While from the geological point it is described as shale, from the engineering standpoint it is no more than hard clay. The material swells and softens in the presence of water and, therefore, the shale surface is softer than the underlying material. Arbitrary zones described as soft, medium and hard have been established to assist in studies. The soft shale is subject to slides and movements and one rather extensive slide area occurs immediately upstream of the site on the left abutment. Very extensive studies have been carried out to determine what slopes will be stable, both from the standpoint of short time construction slopes and long time permanent slopes. Generally, cut slopes in critical areas designed for long time stability are being made as flat as the existing natural stable slopes.

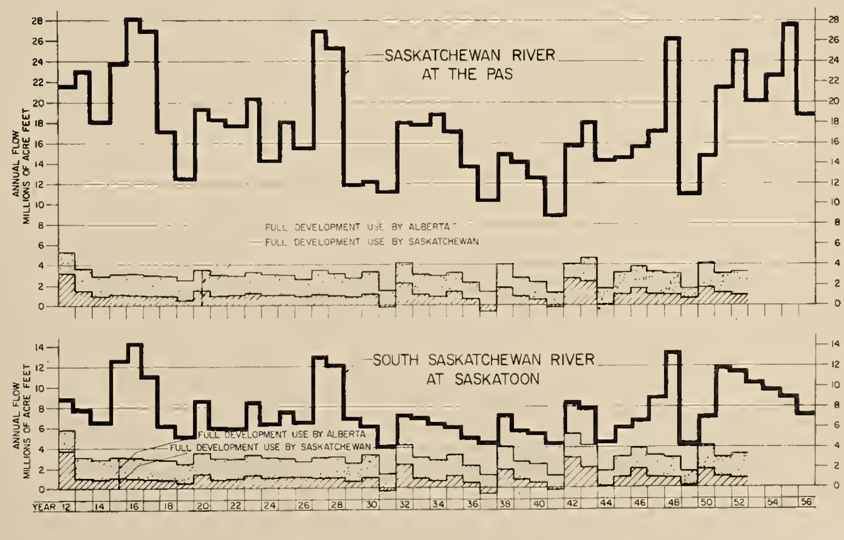
Ample quantities of suitable embankment materials are easily available at the site. The area on the east abutment contains predominantly medium plastic clays suitable for the impervious section of the fill, whereas the west abutment in the plateau area consists mainly of sand and gravel. The pit run sand and gravel is suitable for pervious fill but it requires washing and processing for the filter section and for concrete aggregate.

The Embankment

The embankment is 210 ft. in height and contains about 45 million cu. yd., made up of about one-half impervious and one-half pervious material. It will contain a random section to utilize the miscellaneous materials. The side slopes of the dam are relatively flat in the lower portion. They are about 8:1. These flat slopes are necessary for stability above the river sand in the stream-bed and on the abutments where the soft shale is encountered near the surface. The slopes increase to 2:1 at the crest. The top width is 60 ft. Other important features of the cross-section, which is shown in Fig. 5, are a 1200-ft. upstream impervious blanket, a downstream filter and relief wells. The upstream slope in the drawdown range will be protected by a 3 ft. layer of rock riprap.

The foundations in both stream-bed and on the abutments have been given careful study. Fig. 6 shows a centerline profile with typical test borings. One of the major problems was the type of cutoff through the river-bed sand. Steel sheet piling was first considered but laboratory tests and experience on similar projects have indicated that such a cutoff is relatively ineffective, particularly in a case such as this where boulders were encountered by drilling on the sand-bedrock contact. Consideration was given to a positive type cutoff through the river sand by backfilling a trench unwatered by well points. This was considered both difficult and costly, and probably unnecessary. A final decision was made in favour of a rather extensive upstream blanket. Studies showed that without a blanket the estimated quantity of seepage would be about 20 c.f.s. and that this would be reduced to 13 c.f.s. with a blanket.

Fig. 3. Annual Natural Flows



The steel sheet piling would have little effect on the quantity of seepage unless the interlocks became corroded or were rendered watertight by plugging with clay or silt. To control the seepage, a downstream filter will be utilized and, in addition, relief wells will be placed along the downstream toe. In view of the fact that there appears to be little, if any, sand in a loose condition, stability of the river sand will not be a problem with the very flat slopes on the dam and with seepage pressures controlled by the filter and relief wells.

Stability studies based on the shear strength of the soft surface shale indicate that flat slopes will be required in the shale and on the abutments where shale is exposed. The trim adjacent to the ends of the embankment in the natural shale slopes will be laid out so as not to steepen the existing slopes and, in some instances, flattening will be carried out. Where possible, slope flattening will be accomplished by addition of material in the toe area rather than by excavation of the upper portion of the slope.

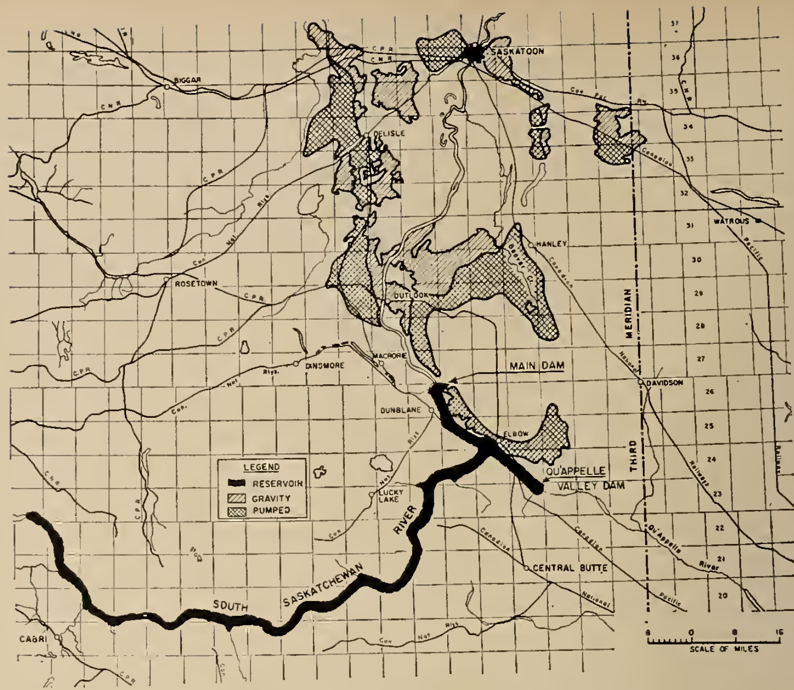


Fig. 4. Map of the Reservoir and the Irrigable Areas

Diversion Structures

In order to construct the closure section of the earth dam in the riverbed, it is necessary to divert the river around the construction area. Because of the large flow to be handled and other difficulties, this has proven to be one of the major site problems from the standpoint of design and cost. Tunnels through the abutments and conduits through the base of the fill have been studied in detail. A decision has now been made to use reinforced concrete-lined tunnels through the west abutment. Five tunnels, 20 ft. in finished diameter, are at present planned. The average length will be 4,050 ft. The tunnels will be located entirely in shale and, in order to have sufficient cover of hard shale above them, the main portion will be depressed about 30 ft. below river level. The profile of the tunnels is shown on Fig. 7. One of the major problems in connection with the diversion structures has been the stability of the cut slopes adjacent to the inlet and the outlet ends. While relatively steep construction slopes will be permitted, final permanent slopes will be no steeper than the present existing slopes in the area.

The tunnels may be used as penstocks for the power plant. In any case, they will probably be maintained as permanent structures and will be used either as penstocks for the power plant or for emergency use or for riparian water discharge. They will, therefore, be provided with a raised inlet and provision will be made to carry water from the river to the inlet through a temporary cut or through tempoary conduits or tunnels. The tunnels will be equipped with control gates located in a shaft near the axis of the dam.

Spillway

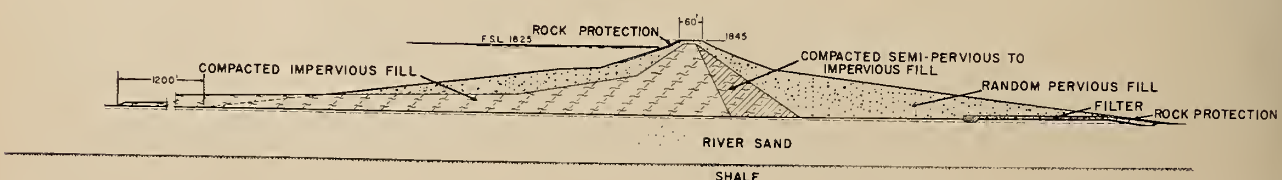
The spillway will be a reinforced concrete chute with a gated crest. it will be about one mile south west of the dam. The inlet channel will be through Hudson's Bay Coulee and the discharge channel will follow Coteau Creek.

The spillway will be designed to discharge a reservoir inflow flood of 400,000 c.f.s. and a total volume of 4 million acre ft. in 16 days, with a pool rise of 5 ft. above the full supply level of the reservoir. The discharge capacity required to meet this condition is 265,000 c. + s.

The spillway chute will be hourglass in shape, 3,000 ft. long, with a gross crest width of 528 ft. The crest will be gated, with 11 radial type gates, each 29 ft. high and 40 ft. long. The chute will terminate in a stilling basin designed to contain and control the hydraulic jump at all discharges.

The lower portion of the spillway will be excavated in the bear-paw shale. Exact final location has not been determined but it will require a deep excavation in the shale. It is planned to make this excavation early in the construction program so that most of the elastic rebound will occur

Fig. 5. Cross-section of the Dam



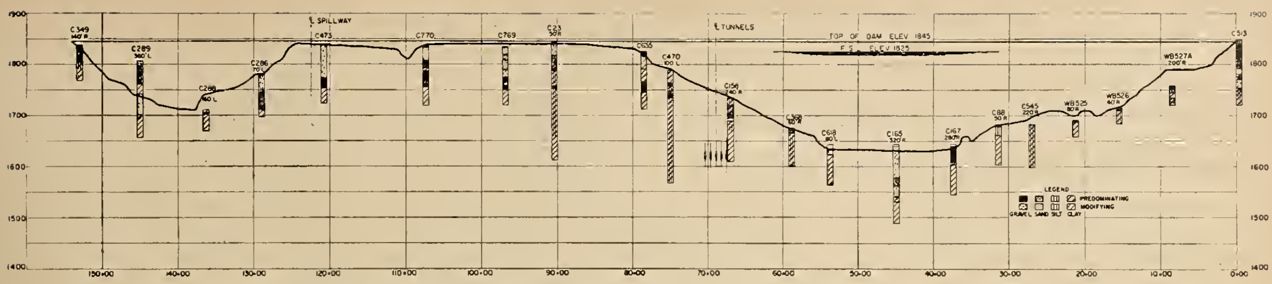


Fig. 6. Centreline Profile showing Typical Test Borings

before the stilling basin is constructed. The stilling basin and any portion of the chute which might be on shale will be securely anchored by concrete hold down piles.

Irrigation Outlets

The water for irrigation will be delivered to the irrigable area in two large canals, one on each side of the river. This will require gated outlets on each side, the design of which is not yet final.

Power-House

In the original planning it was assumed that the tunnels would be converted into penstocks and that the power-house would be located at or near the tunnel outlets, in which case the portion of the tunnels downstream of the gate controls would be lined with steel. More recently, consideration is being given by the Saskatchewan Power Corporation to locating the power-house further downstream and constructing a power canal to transmit the water to the downstream location. Final decision has not yet been made.

Construction

The work of constructing the dam and reservoir will be performed under several unit price contracts of varying magnitude depending on their nature and location. Already several contracts have been awarded for such items as access roads, administration headquarters, concrete aggregate preparation, a construction bridge and the first stages of the embankment construction.

Final river closure will be effected in the section spanned by the construction bridge and the bridge will be utilized for that purpose. River closure is expected in 1963.

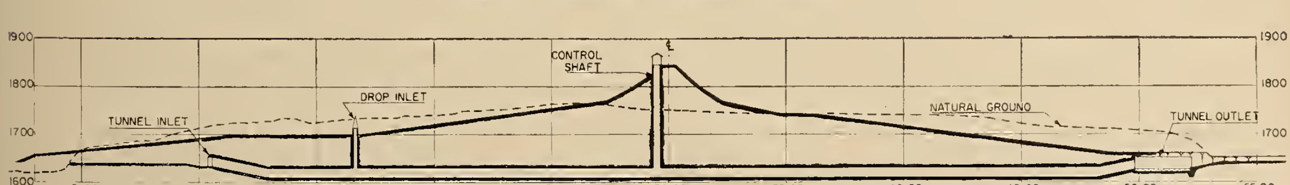
It is anticipated that the construction will require seven full construction seasons and, therefore, completion is expected in 1965.

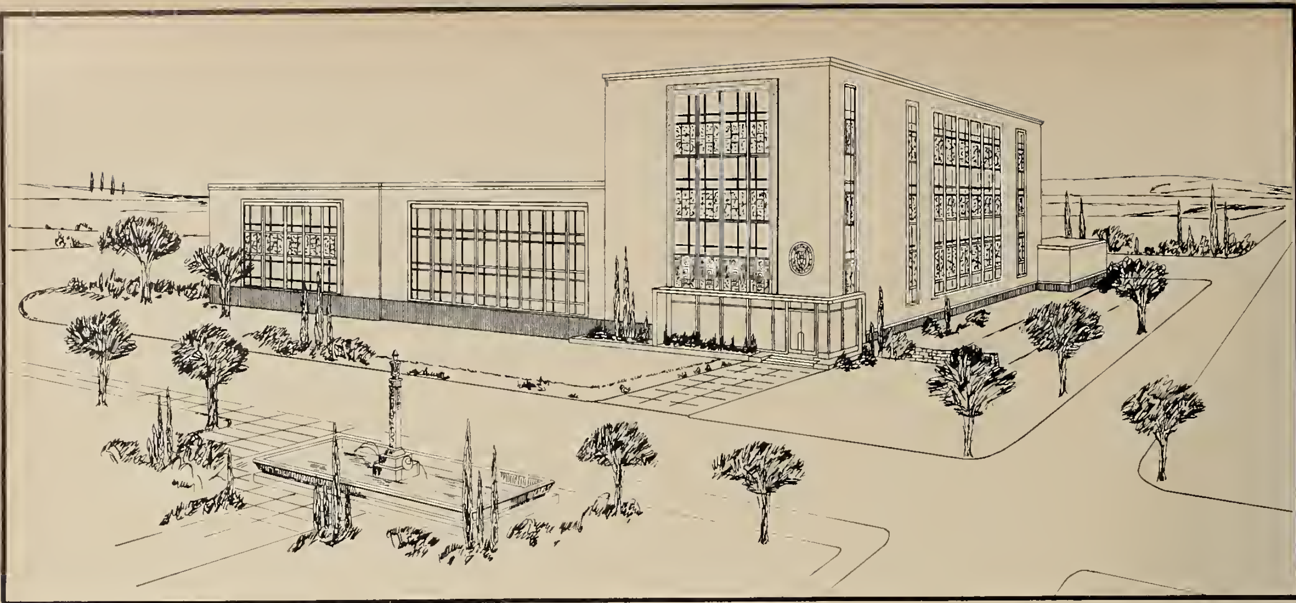
Administration

The agreement between Canada and Saskatchewan provides that Canada will be responsible for all administration and engineering services for the construction of the reservoir. The Prairie Farm Rehabilitation Administration of the Federal Department of Agriculture, with headquarters in Regina, Saskatchewan, has carried out all preliminary investigations and preliminary planning and has been given full responsibility for final design and construction for the Federal Government.

Mr. G. N. Munro, M.E.I.C., is Chief Engineer of the Prairie Farm Rehabilitation Administration and Mr. J. G. Watson, M.E.I.C., is Assistant Chief Engineer and is Project Engineer for the South Saskatchewan River dam. Mr. R. Peterson, M.E.I.C., Chief of the Soil Mechanics and Materials Division of the P.F.R.A., is responsible for all investigations and plans and specifications pertaining to design and specifications of the fill and the foundations. Original design was carried out under the direction of the late Mr. G. W. Parkinson, M.E.I.C., and Mr. W. M. Berry, M.E.I.C., is now in charge of the design of all structures. Mr. W. B. Thomson, M.E.I.C., is engineer in charge of construction.

Fig. 7. Profile of Diversion Tunnels





A DEEP PUMPING STATION FOR THE OTTAWA SEWAGE TREATMENT PLANT

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Paper presented at the Regional Meeting of the Engineering Institute of Canada in Ottawa, October, 1959.

The council of the Corporation of the City of Ottawa early this year authorized the commencement of the design of the first stage of a pollutional control program for the City and surrounding area, including intercepting and sanitary trunk sewers, and a sewage treatment plant of the primary type with sludge treatment—a program estimated to cost approximately $21 million, of which the expenditure on the plant represents about 40% of this amount. The plant is designed to treat raw sewage at the rate of 40 million gal. per 24 hr., such flow deriving from an estimated population of 375,000 persons anticipated by 1975, but with provision for expansion to ultimately serve 590,000 persons, considered to be the eventual population resident within the green belt in the Greater Ottawa Area. Initially the plant will provide only primary treatment but will be designed to be extended at a later date to give complete treatment of the activated sludge type to all tributary flows.

This paper describes in general the sanitary engineering design of the plant and the detailed design of the first phase of the work—the main pumping station. The problems associated with the design of a 75 ft. deep main pumping station insofar as they relate to soil conditions, structural, mechanical and electrical treatment, are described and the actual designs employed to meet the conditions are outlined.

IN JANUARY of 1958 the Council of the Corporation of the City of Ottawa authorized our firm "to carry out the required services necessary to determine the volume of sewage now to be treated in the City of Ottawa, the solids and B..O.D. contents of the sewage, the estimated flow at present and ultimately, the supervision of borings and all other matters necessary to determine the design and estimated cost and to furnish a report accompanied by such preliminary plans as would enable the City to submit to various authorities applications for approval" with respect to the proposed Ottawa Sewage Treatment Plant. Similarly Council authorized others to prepare a report on the proposed Ottawa River Interceptor and Outfall Sewer.

The foregoing authorizations resulted from the insistence by the Ontario Water Resources Commission that the City take immediate action to control the discharge of sewage and industrial wastes from its sewerage system to the Ottawa River. Such decision was based on the pollutional survey of the River carried out by the Commission in 1955 and later referred to in this paper.

After six months study these reports were presented to the Council and in January of this year the design of the first stage of these works was authorized. The current authorization for the design of the sewage treatment plant applies to the main pumping station. It is to the design of this station that the greater part of this paper is devoted. For clarity, however, a complete description together with design factors of the sewage treatment plant as initially planned is presented.

Tributary Area and Population

The tributary area to be served by the Ottawa Sewage Treatment Plant can be best described as the inner limit of the "Green Belt" area proposed by the National Capital Commission. Although such limit at the time of making our report was only proposed, the Memorandum On Boundaries And The Use Of The "Green Belt" prepared by the previous Federal District Commission stated "that the limits of the Belt had been set so as to permit the extension of the Metropolitan Core to the practical economic limit of all municipal sewer and water services". Accordingly, it was only reasonable that it be used in defining the limits of the area to be ultimately tributary to the proposed sewage treatment plant.

Studies indicated that eventually the tributary area could be divided into fourteen separate tributary sections, as set out in Fig. 1. The boundaries of these sections are fixed by the actual layout of the sewers, where these were already in existence, and by general topography in areas which are not yet sewered. It includes a total of about 39,500 acres, including all of the City of Ottawa, the Town of Eastview and the Village of Rockcliffe Park and portions of the Townships of Nepean and Gloucester.

A study of the existing land use of the tributary area was made from up-to-date aerial photography, augmented by on-site surveys where necessary, and as a result it was determined that the area contained in 1958 a population of approximately 257,000 persons or about 43% of its estimated ultimate development. It was obvious that the greatest concentration of population lay within the old City Limits and in Rockcliffe Park and Eastview, and that future growth would be concentrated for the most part in the more recently annexed areas of the City and in the tributary sections of Gloucester and Nepean Townships.

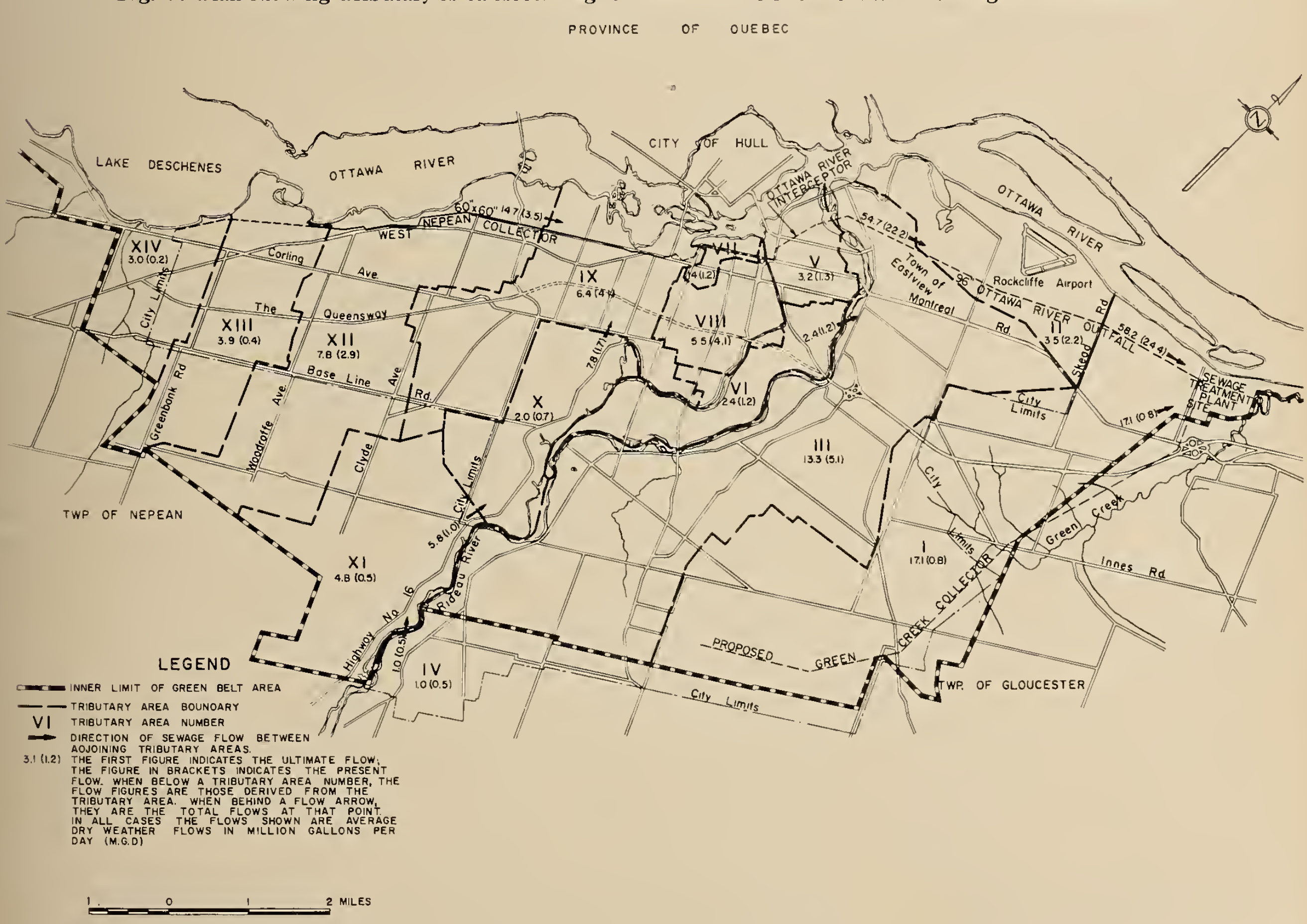
In order to properly assess ultimate sewage flows it was found necessary to compile an ultimate land use plan. Zoning by-laws prepared by the Planning Board of the City of Ottawa formed the basis of this analysis, together with information furnished by the National Capital Commission. From the foregoing, present and ultimate land use tables for the tributary area were prepared with division according to residential, commercial, industrial, park land, special use, institution, road, government buildings and vacant land acreages. From these land use studies and on the basis of previous studies in the area including works carried out by the City Assessment Department, the City Department of Planning and Works, and the National Capital Commission, a forecast of population growth for the tributary area was compiled. This indicated that a population of 375,000 might exist in the area under study by 1975 and that it was possible for an ultimate population of almost 600,000 people to be resident within the area, representing a gross density of approximately 15 persons per acre.

Design Flow and Sewage Strength

The land use divisions outlined above corresponded with records of the sale of metered water maintained by the City Water Department. It was also possible from the water meter records to determine the anticipated unit sewage flows on an area basis for each type of use, both now and in the future.

Then from the foregoing ultimate land use acreages and the acreage rates of sewage discharge for various pursuits, the sewage flows for present, near future and ultimate conditions were estimated. In an effort to obtain reliable infiltration allowances to use in establishing the estimates, to provide an approximate check on them, and to ascertain the approximate strength of the sewage to be treated, gauging and sampling were carried out in the Rideau Canal Sewer and the John Street Sewer, two main sewers in the City of Ottawa. The results proved most valuable and considerably strengthened the reliability of the estimates. On the basis of these studies it was apparent that if all developed sections of the tributary area were currently serviced an average sewage flow of 25 million gal. in 24 hr. would obtain approximately 97 gal. per capita per day. On the basis of ultimate development, however, a flow of 75 million gal. daily was indicated derived from a population of 590,000 persons and representing a daily per capita flow of 127 gal. indicating the anticipated increasing use of water and certain industrialization in the future Ottawa. Accordingly, in view of the existing and estimated ultimate populations of the area and the present and forecasted sewage flows, it was recommended that initially a plant capable of treating a daily average flow of

Fig. 1. Plan showing Tributary Area According to Sewer Districts to the Ottawa Sewage Treatment Plant.



40 million gal. of raw sewage derived from an estimated population of 375,000 persons be constructed.

On the basis of sewage analysis carried out and assuming future regulation under a municipal sewer ordinance of industrial waste discharges that might develop, it was recommended that the plant be capable of treating sewage having an average Biochemical Oxygen Demand (5-day) of 200 parts per million and an average suspended solids content of the same value. It was estimated that the tributary population would be in existence by 1975, and accordingly it was recommended that the plant be so laid out that it could be extended in two further stages to an ultimate capacity of 75 million gal. per day. Studies carried out indicated that such flows would reach the plant through the immediately proposed Ottawa River Outfall Sewer and the future Green Creek Collector and that on the basis of ultimate average flow 58 m.g.d. would be derived from the former and 17 m.g.d. from the latter.

Peak flows will vary for each since the Ottawa River Interceptor will intercept primarily the old combined sewerage area of the City while the Green Creek sewer will serve entirely a separate sewerage area.

The cost of works to provide for the treatment of large storm flows would be prohibitively expensive even if treatment of such large volumes of diluted sewage flows were scientifically feasible, and a study of the flow to be provided for in the combined sewerage area, having regard for this cost, indicated that a peak flow of 2.5 times average dry weather flow is the most feasible and practical. The amount of raw sewage escaping to the river under these conditions would be 2.2%.

On this basis and allowing a peak of 1.7 times average dry weather flow for the separate system an overall ratio of peak flow for treatment to average D.W.F. of 2.2 was derived.

Plant Site

The site of the sewage treatment plant had been previously discussed in a report rendered to the City some 11 years ago. This report noted that the logical site for a sewage treatment plant was the broad expanse of flat ground bordering the right bank of the Ottawa River between the proposed railroad and highway bridge over Duck Island on the west and Green Creek on the east. The site lies in the extreme north-east section of the urban area and is favourably located in respect to the latter. Also it offers a favourable point from which to dispose of treated sewage into the Ottawa River. The site is readily accessible and yet is well removed from all existing or probable populous areas.

Acting on the basis of that initial report the City made application some years ago to the Ontario Department of Health for permission to construct the proposed plant on a site of 320 acres in the indicated location in Gloucester Township.

Our review of that proposed site, which the City had previously purchased in part, indicated that only one alternative site could be considered at all feasible. This area which was to the west of the proposed site was however found to be impractical for development because of its location in line with Rockcliffe Airport runway, and the restriction imposed on the sludge, grit and screenings disposal by the adjacent residential development. Having in mind all aspects of the problem, even including soil conditions, the site currently owned by the City on the northwest bank of Green Creek adjacent to the Ottawa River was without question the most suitable in all respects for the establishment of the proposed sewage treatment Plant.

The Receiving Body—Ottawa River

A study of the hydraulic data on the Ottawa River furnished by the Federal Department of Northern Affairs and Natural Resources indicated that in the area of the proposed plant location an annual mean flow in the Ottawa River of 50,000 to 60,000 c.f.s. could be anticipated, with a mean low month flow of 30,000 c.f.s. generally obtaining. On the basis of such figures and the dilution offered to a plant effluent of the volume anticipated, it was obvious that at least initially, only a plant of the primary type for the treatment of municipal sewage comprising sedimentation and chlorination would be practicable, with complete treatment to be anticipated at some time in the future.

This was confirmed by studies carried out by the Ontario Water Resources Commission in 1955. In this study, bacterial counts as high as 100 times the maximum objective of 2400 coliform per hundred millilitre sample were recorded in the Ottawa River despite the heavy dilutional flow of the river. In addition, biochemical oxygen demand as high as 28 parts

TABLE I
BASIC DESIGN DATA

ESTIMATED FLOW (million gallons per 24 hours)

	Immediate	Initial Design	Ultimate Design
Population	258,000	375,000	590,000
Average Flow	25	40	75
Maximum Monthly Flow	31.3	50	93.8
Maximum Peak Hour	58.0	88.0	156.0
Minimum (for less than 1 hour)	15	24	45

ESTIMATED SEWAGE STRENGTH

	Raw Sewage ppm	Primary Percentage Removal	Treatment Settled Sewage–ppm
Suspended Solids	200	53	94
Biochemical Oxygen Demand	200	32	136
Grease (ether soluble)	60	50	30

SLUDGE DIGESTION

3 tanks each 110 ft. dia. x 24 S.W.D.
Total volume . . . . . 684,000 cu. ft.
Unit volume per capita . . . . . 1.83 cu. ft.
2 primary tanks, 1 secondary tank. All tanks have fixed covers. Separate spherical holder for gas. Gas recirculation on primary tanks.
Approximate detention at 375,000 persons . . . . . 40 days

PRIMARY SETTLING TANKS

6 units, 37 ft. wide, 10 ft. swd., 180 ft. long
Total volume . . . . . 400,000 cu. ft.
Retention at 40 mgd . . . . . 90 mins.
Surface loading at 40 mgd . . . . . 1000 gpd./sq. ft.
Weir overflow rate at 40 mgd . . . . . 21,200 gpd./lin. ft.

SLUDGE DISPOSAL

Complete lagooning of sludge.
30 month retention.
Initial depth of lagoon . . . . . 4 ft.
Approximate acreage for 375,000 persons 30

PRE-AERATION AND GRIT REMOVAL

2 units, single pass, each unit 180 ft. overall length, 15 ft. S.W.D., 30 ft. width
32 ft. of length for grit removal
148 ft. of length for pre-aeration
Total volume for pre-aeration . . . . . 66,600 cu. ft.
Retention time at 40 mgd . . . . . 30 mins.
Air supply at 40 mgd . . . 0.065 cu. ft./gal.

CHLORINATION

Prechlorination, Post chlorination, Sludge chlorination 4 units at 8000 lbs./day
1 unit at 2000 lbs./day . . . 34,000 lbs./day
Dosage at 40 mgd. at 20 ppm . . . . . 8,000 lbs./day
Detention in outlet at 88 mgd . . . . . 7 mins.
Detention in chlorination chamber 10 mins.

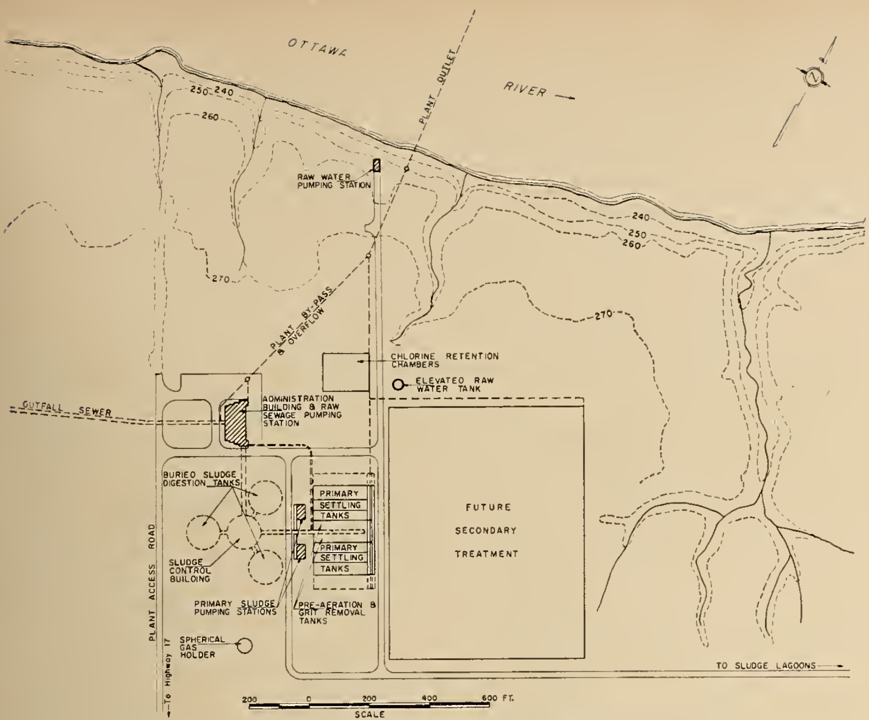


Fig. 2. Main layout of Ottawa Sewage Treatment Plant.

per million was encountered in the Ottawa area, representing a waste strength of almost 20% of normal domestic sewage, despite the dilutional effect of the flow. Indeed, the Ontario Water Resources Commission stated that taken altogether the results of the analysis conclusively indicated that the Ottawa River below Chaudiere Falls was quickly transformed into a heavily polluted river.

Further, the report indicated that the heavy discharges of untreated sewage and industrial wastes in this stretch of the river had rendered the water unsafe for use as a public water supply without complete treatment and hazardous for recreation and fish life. It is interesting to note however, that it did indicate that at least 80% of such pollution was due to the potential waste discharged by the pulp mills located on the Quebec side of the river in the Ottawa area.

The report of the Ontario Water Resources Commission recommended that remedial measures be undertaken in the Ottawa area without delay and that these measures must be sufficient to restore and protect the uses of these waters to which the people of both provinces were rightfully entitled. It further recommended, that treatment of municipal sewage by sedimentation and disinfection of the effluent be undertaken immediately to be followed by a biological process to complete the task at a later date.

Initial Plant

Accordingly, after a complete review of the data on hand and the conditions obtaining in the area our firm recommended that ultimately a complete treatment plant of the activated sludge type be installed by the City, but that for the present only the primary treatment portion of this plant including sedimentation and chlorination be built. Later, with the implementation of a pollutional control program on the Quebec side of the river thereby giving all waste discharges at least primary treatment prior to discharge, it would be possible to re-evaluate the condition of the river and determine when complete treatment had to be adopted by all concerned.

Ultimately the City Council acting on the recommendation of Board of Control decided that the plant should be built as a primary type as recommended with provision included for expansion to treat increased flows and to provide biological treatment through the use of the activated sludge process.

Basically, the Outfall Sewer was to parallel the Ottawa River picking up the main points of existing discharge from the City of Ottawa and carrying the flows to the plant site immediately west of Green Creek on the bank of the Ottawa River. As previously indicated this interceptor would carry an average of 58 m.g.d. or approximately 75% of the ultimate sewage flow to the plant.

It became obvious however that in order to carry sewage to this point and pick up all present and future discharges by gravity the sewer would terminate on the plant site at an elevation of approximately 108 (Geodetic Datum) as compared to a grade on the proposed site of the plant varying between elevation 160 and 170 and a variation in river level itself of elevation 130 to 140. In this situation, one of the major recommendations of the report was therefore the construction of a raw sewage pumping station on the proposed site which would include coarse and fine screening equipment and raw sewage pumps to lift the sewage to the treatment units. It was proposed that following this station pre-aeration with grit removal would be installed, the sewage flow passing on to primary sedimentation tanks equipped with grease collection and sludge removal equipment, the effluent to be eventually discharged to chlorine retention chambers where it would be chlorinated prior to discharge to the Ottawa River at depth through a plant outlet sewer. Sludge removed from the primary sedimentation tanks was proposed to be digested and lagooned in the large areas available at the site for ultimate disposal as a soil conditioner.

The disposal of the solids removed as sludge in the primary settling tanks of the Ottawa Sewage Treatment Plant represents a most costly portion of the project and that which might be termed the most difficult. Because of being highly putrescible, this sludge could be a serious nuisance to the successful operation of the plant unless properly disposed of.

The purpose, therefore, of processing and disposing of the sludge is to render it unobjectionable and to dispose of it sufficiently rapidly to prevent its excessive accumulation, by reasonably economical methods.

A common idea in the public mind is that fertilizer that can be produced from sludge through vacuum filtration and heat drying will sell on the market at a sufficiently high price to offset considerably the cost of sewage treatment. Nothing could be farther from the truth. An economic study indicated that the cost of filtration and heat drying of sludge for Ottawa would exceed $35 per ton of heat-dried sludge such price including capital and operating charges. At present the best price obtainable on the Ontario market for heat-dried primary sludge is $8 per ton and no fertilizer manufacturer has yet offered a contract based on accepting all plant production. Indeed, across the continent the price for heat-dried sludge has varied so radically and on the whole reduced so substantially in recent years that it is doubtful whether there is a single plant to-day that could not embark on a cheaper process. In such circumstances, the field has been attractive to proponents of the Zimmerman process, a wet oxidation process now being installed in Chicago, and the Atomized Suspension Technique now in operation in at least one municipality in Quebec. These methods represent sludge destruction processes on the whole and only the latter in our opinion shows merit for future application providing its operating costs can be maintained at the level now estimated by the manufacturers. In any case, the A.S.T. process would cost at least $32 per ton of dry solids treated to install and operate.

Accordingly, the digestion of raw sludge under controlled temperature conditions (90°F) thereby reducing, through the action of bacteria gaining their oxygen for their metabolism from the organic content of the sludge, the quantity of sludge from 50% to 60% of the original amount and liberating through this action sufficient gas (Methane primarily) to heat the plant is in our opinion the cheapest and most practicable sludge treatment to be followed in Ottawa. Digested sludge would be dewatered in sludge lagoons located on the plant site to a final moisture content of 40% and be finally disposed of to the parks boards and private homeowners as a soil conditioner. Disposal costs on such basis would be less than $22 per ton treated, including capital and operating costs, and the plant would still be able to adapt to one of the newer processes if and when its economy could be proven. Accordingly, our recommendations on sludge digestion and lagooning have been accepted.

It is not the purpose of this paper to deal in detail with all the various units and equipment that will be included in a plant of this size. As yet the work authorized embraces only the design of the raw sewage pumping station and accordingly, the remainder of the paper will deal in detail with this station. However, to clarify the matter of the design of the proposed plant, Table 1 indicates the design factors of the various phases of the plant as intended, and Fig. 2 outlines the main layout of the plant as proposed.

Soil Conditions

Prior to March, 1958, no extensive investigations had been made in the relatively level area east of Skead Road between Montreal Road and the Ottawa River;[1] consequently no information had been recorded which afforded assistance in establishing reliable criteria for the detailed design of the structures to be built in the first phase of construction of the Sewage Treatment Plant or indeed for the preliminary design of the remaining structures to be built in subsequent phases of construction of the Primary Treatment Plant and its extension as already described to provide additional facilities for complete treatment.

A study of the geological history of the area revealed that glacial ice had covered the entire region including the basic rock formation. As the ice receded it left behind a thin layer of till above the bed rock. Subsequently, the sea covered the area and deposited clays in the valleys over the glacial till. These preliminary studies emphasized the importance of a carefully planned and properly executed program of subsurface investigations.

The soil conditions at the plant site, as shown by the preliminary subsurface investigation carried out during March and April 1958, can be described in a general way. A thick deposit of blue clay known locally as 'Leda' clay overlies a thin layer of boulder till with bedrock beneath. It is probable that the ground water varies from the surface to a depth of 10 ft. below. The adjacent Ottawa River water level varies from about 25 ft. to 45 ft. below the ground surface elevation at the site of the deep sewage pumping station.

The 'Leda' clay is highly plastic, compressible although preconsolidated, generally stiff, very sensitive, with some organic layers. It loses almost all its strength or stability when disturbed, remoulded or reworked, indeed to the extent of becoming semi-liquid. Its thickness varies from 50 ft. to 100 ft., and its surface is most susceptible to gullying.

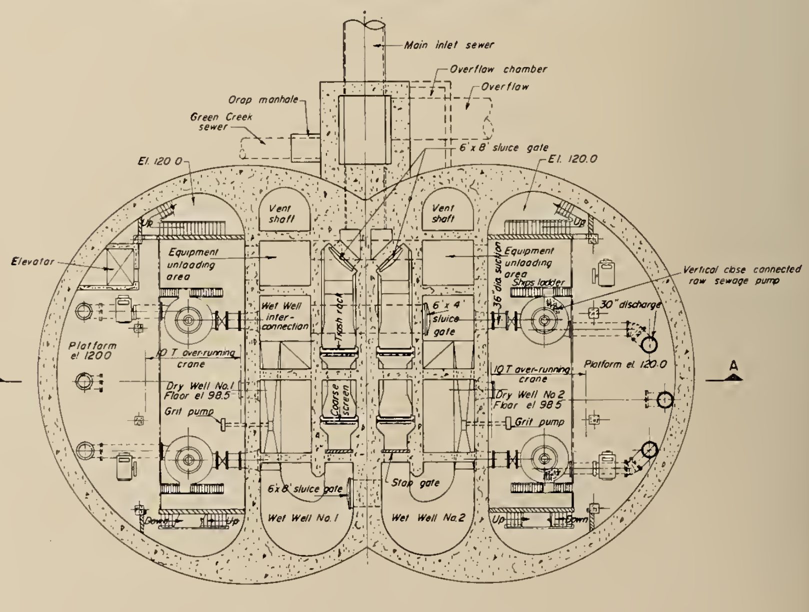
The underlying glacial boulder till is a mixture of silt, sand, gravel and boulders with densities varying from loose to very dense and may contain sand or gravel water bearing layers. The thickness of the till varies from a few feet to a maximum of 15 ft.

The bed rock is Dolomite of the Oxford formation which is generally massive with its top layers weathered. The rock surface is between 85 and 100 ft. below grade.

During construction the control of ground water will be a major consideration, especially in the excavation for the deep raw sewage pumping station. The possibility of small acquifiers in the clay cannot be overlooked. It is probable that the till and upper layers of the bed rock may be carrying water under a head which would lead to uplift and piping in the bottom of the 80 ft. deep excavation.

In the above noted deep excavation the problem of bottom heave will be met. This means that a condition exists whereby the clay has insufficient shear strength to resist the effect caused by the adjacent head of clay outside the sheeting imposing a load on the bottom of the excavation tending to heave it upward.

Fig. 3. Plans of Raw Sewage Pumping Station.



PLAN ABOVE ELEV. 120.0

Special consideration is required in the problem of placing backfill around structures.

Limitations are placed on methods available for piled foundation treatment when considering the type of till material through which piles are to be placed.

Because of the nature of the sensitive clay an accurate determination of its bearing capacity will be required for the construction in the future of the hydraulic structures not founded on rock. Total settlements, heaving and differential movements must be estimated to permit the design of these structures.

Due to the susceptibility of the soil to gullying, special precautions are being taken in the design of the surface drainage system for the entire site.

Following the preliminary soils investigation the locations of the various structures were accurately determined, and having regard for the unusual soil conditions, foundation elevations were set. When the field survey grid lines were laid out on the site, a detailed subsurface investigation program was planned. Owing to the importance of soil conditions at this site, it was decided to have a review made of the preliminary findings by an internationally renowned engineer specializing in the soil mechanics field, and to seek confirmation of the proposed detailed investigation. Accordingly, Dr. A. Casagrande of Cambridge, Massachusetts, was consulted in March, 1959, by the soil consultants and ourselves, and a basic detailed investigation was established embodying the use of piston type samplers, drilling mud and the obtaining of 3½ in. or 4 in. diam. clay samples. It is considered that the larger diameter should be used to obtain the best quality of samples in view of the sensitivity of the clay involved. Two large boreholes are to be put down at the site of the raw sewage pumping station to extend through clay, till and into the rock to investigate the thickness and character of the till soils and the elevations of the rock. In addition, a test well will be drilled into the rock and pumping tests performed, using adjacent holes as observation wells. This test will determine groundwater conditions and assist in evaluating the effectiveness of dewatering during construction by deep well pumps. The balance of the final investigation consists of the normal procedures of drilling, sampling and analysis of the soil conditions at the locations to be occupied by the sludge digestion tanks, the sedimentation tanks, the future aeration tanks, the raw water pumping station and the marine section of the plant outlet in the Ottawa River. This program is now well underway and the information obtained is being used as confirmation or revision to design criteria adopted as a result of the initial program findings.

Raw Sewage Pumping Station

General: As in the case of many of the larger sewage treatment plants, the raw sewage reaching the plant from the Ottawa River Outfall Sewer must be lifted from a considerable depth below ground to a sufficient height above ground level to permit the establishment of treatment units at an economical level.

The cost of the pumping station and the power costs for pumping are both functions of the depth of the station, and an increase in depth shows a corresponding increase in the costs of both of these items. On the other hand an economy can be effected in the cost of the incoming sewer by increasing its depth at entry to the station and thereby increasing its grade and reducing its diameter.

A study was carried out to determine the optimum depth of the pumping station, and it was established that an economical balance would be reached using an 8 ft. diam. sewer with an invert elevation of 108.0 and a wet well established 10 ft. below this point to maintain a low pump suction head under all conditions of operation.

The layout as shown in Fig. 3. and Fig. 4. is based on the use of divided wet wells so that the plant may continue in operation while one well or its screen chamber is shut down for cleaning. Facility will be provided for cleaning out all screen and wet well chambers with motor operated clam buckets carried on crane rail units. Also small independent sump pumps will be installed in the wet wells to permit the drainage of the lower levels of the pump sumps.

A vertical overflow shaft and conduit will be provided at the entrance to the screen chambers which will be capable of diverting excess flow over and above that which can be handled by the pumps and will further provide relief for any surge condition which might arise in the event of a sudden shut down of the pumps. This shaft has also been sized to facilitate the extraction of the tunnel shield which may be used in the construction of the incoming sewer.

A full stairway and elevator system will be constructed from the lowest point of the dry well to the highest floor. High capacity submersible sump pumps will protect the dry wells from flooding.

On the main floor level of the station will be located the entrance lobby, the chlorine storage room, and the plant personnel room. Administration and laboratory facilities and the control room will be located above the main floor level at one end of the building with the chlorine equipment room and potable water treatment unit at the other end.

Intermediate floors below ground level will contain the screening room, the electrical switchgear and transformer rooms, and the boiler and air conditioning rooms.

Structural: From the foregoing it is apparent that the station will extend to a depth of approximately 80 ft. below ground level.

In view of this considerable depth, the unusually sensitive nature of the Leda clay, and the high water table of the site, some careful thought was given to produce the particular structural pattern best suited to the environment. The design problems which these factors present could not be separated from the problems which might be met during construction.

The possibility of performing the excavation in opencut with stable side slopes was investigated and ruled out on the basis of economy—being extremely expensive because of the very flat slope of the Leda clay, and the unsuitability of the clay as a backfill material necessitating the use of large quantities of imported fill. It was therefore decided to base the design on a braced, sheeted excavation.

The problem of whether such a station can be more economically designed on a circular rather than a rectangular plan was examined. Recent designs at Pittsburgh and Philadelphia on similar projects have employed the circular design in order to avoid extensive cross bracing of the primary lining prior to concreting and to maintain wall thicknesses within reasonable limits.

In the Ottawa station the rectangular plan proved to be unsuited to the clear, unobstructed layout envisaged for the dry wells, since the wall thicknesses could only be kept reasonable by "compartmentalizing" the structure in an endeavour to reduce the unsupported spans.

The better layout afforded by the circular plan and the constructional advantages of circular sheet piling influenced the choice of the present layout of two intersecting circular cells.

The walls of the structure have been designed to resist earth pressures calculated with a coefficient of unity and a unit weight of 105 lb. per cu. ft., as these loadings closely approximate the maximum loading conditions of disturbed Leda clay. The wall thicknesses were so calculated that the line of thrust of the earth pressure passes through the middle third of the section. The central division wall separating the two wet wells is reinforced with structural steel to withstand the large unbalanced thrust at the common chord of the two cells.

Unfortunately, under all practical locations for the pumping station, it was not possible to base the floor of the station on rock. In its present location preliminary soil explorations reveal that the underside of the slab will rest on or near the till layer which extends approximately 15 ft. above the rock. Despite the varying densities of the till soils and the possible disturbances which may occur during construction, it is felt that these soils are suitable material for the support of the normal foundation loadings. However, taking into account the considerable concentrated loads which are carried down the main walls of the structure, causing high differential pressures on the base, the present intention is to take the wall loadings directly to rock by means of short bored concrete piles, and to allow the base slab to span between the main walls of the structure.

In view of the high ground water table the hydrostatic uplift on the structure constitutes a major problem. A method of anchoring the structure to the underlying rock by means of prestressed cables encased in bored concrete piles was thoroughly investigated. By this method it was intended to take the full weight of the structure on bored piles arranged around the perimeter and along the central division wall, while the uplift would be taken by the prestressed anchor piles located uniformly over the base of the structure. The cables of the prestressed anchorages would be grouted into the rock for approximately 30 ft. and would of course be protected from corrosion in the till by the concrete surround.

Despite the apparent suitability of the conditions for this application of stress anchoring, it was estimated that the most economical method in both time and money was to add positive weight to the structure by increasing the thickness of the base slab, which will also be capable of withstanding full hydrostatic uplift.

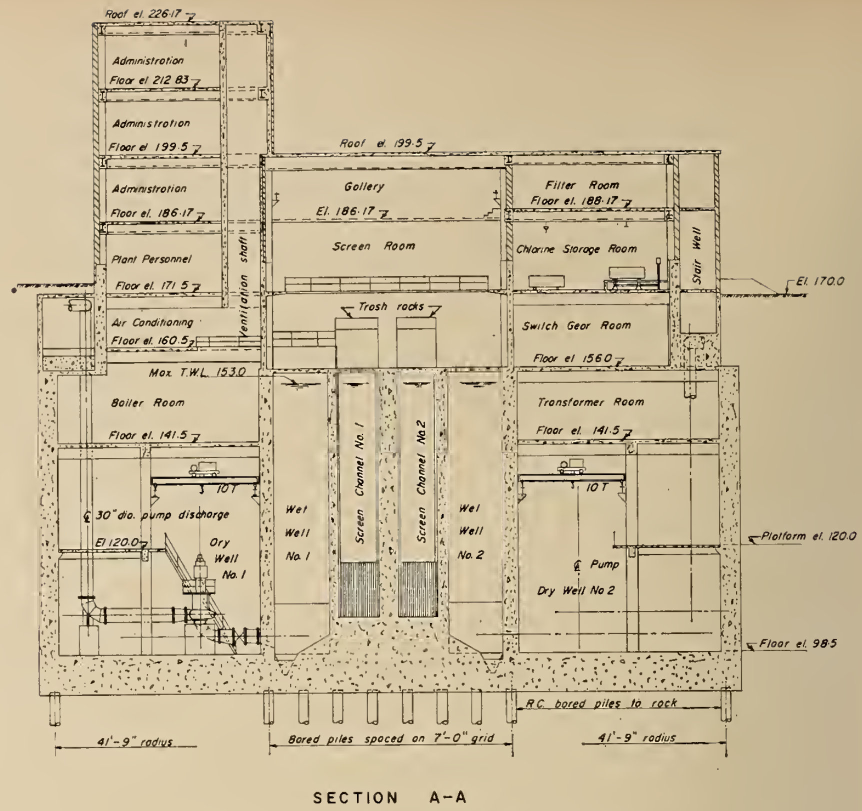


Fig. 4. Sections of Raw Sewage Pumping Station.

Mechanical: (i) *Pumping Units*—Present day practice in major sewage stations demands that the pumping rate be matched within reasonable limits to the sewage inflow in order to minimize the size of the wet well and to maintain a reasonable treatment efficiency. To accomplish this, a varying discharge from the wet well is necessary in order to hold the inflow level to the station as close as possible to the theoretical flow depth in the incoming sewer. Furthermore, facilities for recycling must be provided to ensure that when additional pumping units come into operation there is no sudden large increase in the rate of discharge.

In this instance, a preliminary study was carried out to ascertain whether a matched pumping rate could be maintained by means of pumping units with manually controlled constant speed drives, having regard for the storage capacity of the wet well and the incoming sewer. It was found, however, that flow conditions could not be satisfied and good velocities maintained at the same time without the use of an uneconomically large number of small pumping units.

Accordingly, it was decided to use close coupled vertical centrifugal pumping units employing any one of the three following methods of speed control to permit stepless variation in pump flow capacity within reasonable limits:—

(a) Wound rotor commutator motor, with Induction regulator speed control;

(b) Synchronous or Induction motor with magnetic drive coupling controller;

(c) Wound rotor motor with liquid slip resistance for speed control.

In order to facilitate the selection of one of these combinations, the supply of pumps and drives will be the subject of a separate contract, and the bids will be adjudged with due regard to the overall line to water efficiency as well as to capital cost.

The controllers on the variable speed drives will be actuated by wet well float controls on a recycle program in a similar fashion to that employed recently at Boston and New York.

(ii) *Piping, Valves* — Each pump unit will be equipped with a separate discharge main, and to prevent backflow to any unit out of service gooseneck siphon discharges are provided on each main. With this arrangement expensive check valves on the discharge mains will not be required. The pump discharge is extended above the level in the outlet conduit, then turned down and terminated below the minimum water surface in the discharge conduit.

During the pumping period the goose-neck acts as a true siphon and the static head is measured to the water surface in the discharge conduit. A solenoid operated gate valve is provided at the highest point of the goose-neck to automatically admit air and break the siphon when the pump is stopped.

When the pump has stopped there will be a tendency for the liquid remaining in the vertical limb of the discharge main to return through the pump to the wet well. The impulsive force caused by the sudden change in direction of flow might lead to serious damage to the impeller, and consequently the pumps will in this instance be equipped with a device to prevent reversal of the impeller.

(iii) *Screens and Grinders*: In each of the two screen chambers will be installed one coarse rack with 3 in. spacing followed by one bar screen with 1 in. spacing. Both trash rack and bar screen will be equipped with mechanical back cleaning equipment. Because of the great depth of the screen channels, the vertical type of screen must be used even though the inclined type would provide more efficient screening.

Under normal operation the screenings are collected at the head of each screen and fed by conveyor to a rotary shredder. All shredded screenings will be returned to the flow ahead of the screens.

As an alternative means of screenings disposal the screenings may be collected in tipping buckets located at the head of each screen, and removed by overhead crane to a main container which will be carried to the disposal point by a dump truck.

(iv) *Chlorination Equipment*: Chlorine will, in this first stage of the plant, be applied to the raw sewage immediately before the bifurcation point at the entrance to the wet well. This will also serve as a prechlorination point at a later stage when the primary treatment units of the plant are completed.

Five vacuum type solution-feed chlorinators will be installed in the chlorine equipment room, four rated at 6000 lb. per day per machine and one at 2000 lb. per day. The large machines will have an ultimate capacity of 8000 lb. per day and together with the small machine will be capable of providing for the present minimum and ultimate maximum flows. Three 8000 lb. per day evaporators will be provided to work in conjunction with the above equipment. All chlorinators will be completely manual in operation.

Chlorine cylinders in the storage room will be handled by means of a 2 ton monorail.

(v) *Heating, Ventilation and Cooling*: The plant heating system will be established in the boiler room of the pumping station and in this first stage two steam boilers will be installed. These will be suitable for gas or oil fuel and each will have a capacity of 10,000 lb. of steam per hr. Steam lines will radiate from this point to all heated areas and building heat will be through steam operated unit heaters.

The dry wells of the pumping station will be fitted with humidity control equipment for protection against corrosion through condensation of the main pumping equipment and ancillary fittings.

The whole of the pumping station will be ventilated by a forced draft system. The screenings room will be equipped with an automatic mechanical "sniffer" control and will receive a higher rate of ventilation than the rest of the building. Both air intake and exhaust in this room will be directly to the outside of the building.

Air conditioning will be incorporated in the main building for the administration section only.

Electrical System

In the process of sewage sludge digestion the production of sludge gas has established a practice of gas utilization as a source of power development as well as sewage treatment plant heating. Its use for the development of power can only be justified on the basis of cost comparison with the rates quoted by the applicable electrical utility.

The problem in the case of the Ottawa plant was to determine if the cost of the installation and operation of dual fuel diesel engine-generators could compare favourably with the cost of purchasing power from the Hydro-Electric Power Commission of Ontario, Eastern Region.

Three schemes were considered in order to make the necessary determination as follows:—

A—all power purchased;

B—purchased power for all plant requirements except pumps operating above minimum capacity which would be powered from dual fuel diesel engine-generator sets;

C—all power developed by dual fuel engine-generator sets.

On the foregoing basis the capital cost of engine generator sets rules out their application to the Ottawa problem. Accordingly, all power for plant use will be purchased from Hydro.

Discussions with officials of Ontario Hydro, Eastern Region resulted in an arrangement whereby a new transmission line will be built to deliver power at 12 kv. to the transformer vault in the Main Building.

At the Main Building transformer vault three sets of transformers will be provided to reduce voltage from 12,000 v. to 2400, 600 and 208/120 v. as required. The electrical system is single split bus radial system planned for power distribution at 600 v. to motor control centres located in the structures to be provided in future contracts. Power will be distributed underground at 2300 v. to future equipment required for secondary treatment.

All 600 v. motors will be started on full voltage by circuit breaker type combination starters. Exterior lighting will be mercury vapour on steel poles.

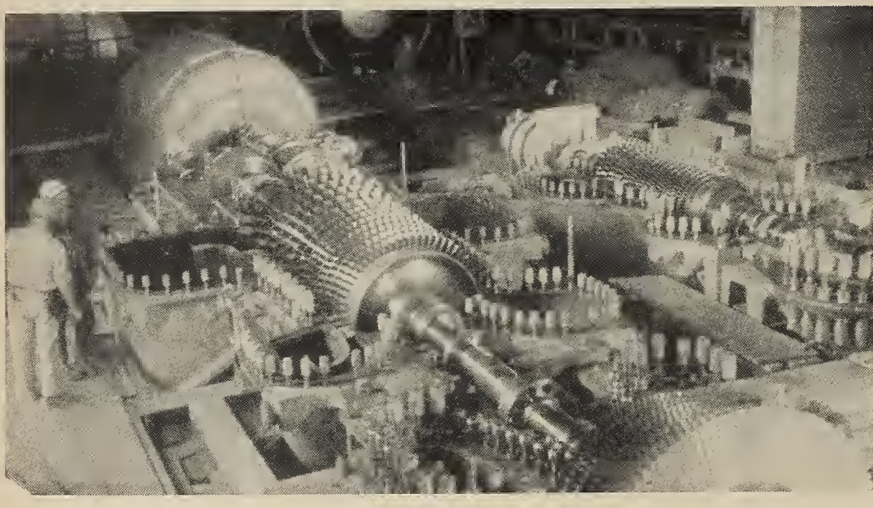
A central operating panel will be erected in the main control room on which all indicating, totalizing and recording units will be erected. Further, a diagrammatic panel indicating the operation of the plant in colour coding will contain miniature indicators showing total flow rates and key valve and gate positions. To further facilitate the control of operation of this plant, telephone communication will originate from this room to all key points of the plant.

The cost of the primary treatment plant as outlined here is estimated at $8,650,000 with the first phase, the raw sewage pumping station and ancillary works being estimated at $3,600,000. It is estimated that a total assigned personnel of 28 men will be required to operate the plant and that at design flow the annual plant operating cost will be about $400,000 per year.

Acknowledgment

The program is being carried out under the direction of Mr. F. E. Ayers, Director of Planning and Works for the City of Ottawa, through whose kind permission this paper is presented. Mr. W. L. Keay, Engineer in Charge of the Sewerage Branch of the Department of Planning and Works, is in immediate charge of work which is being designed by James F. MacLaren Associates, Toronto, with G. C. McRostie and Associates of Ottawa acting as soil consultants, Professor Arthur Casagrande of Cambridge, Massachusetts acting as soils adviser and with D. E. Kertland, Toronto, acting as associating architect.

SOME FEATURES OF THE PORT MANN GAS TURBINE GENERATING STATION



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In February this year, the first unit of the 100 mw. Port Mann gas turbine generating station came into service on the B.C. Electric Company's system. The station is fully automatic, unattended and controlled remotely from a control room in the Head Office some 15 miles away. The paper outlines some of the technical and economic features of the Port Mann gas turbine plant.

The prime function of the plant is to supplement hydro generation under adverse water conditions. Its secondary function is to provide standby for outages and peak loads of short duration. The Port Mann installation comprises four Brown Boveri 25,000 kw. two-shaft open cycle units with one stage of intercooling between high pressure and low pressure compressors. It is located approximately 3 miles East of New Westminster, in close proximity to an existing natural gas pipeline, an oil pipeline, a high voltage transmission line, rail and road facilities, and an adequate supply of coolng water from the Fraser River. The primary fuel is natural gas, supplied under an interruptible contract. On those occasions when the gas supply is cut off, the turbines will run on crude oil. A standby oil tank with a tap to the Trans Mountain Oil pipeline is provided for this purpose. Each gas turbine drives a 30,000 kva., 0.9 pf., 13.8 kv., 3,600 r.p.m. air-cooled turbogenerator. Power is fed from the single 13.8 kv. bus through two 50 mva., 3-phase transformers to an adjacent 230 kv. transmission line. The plant is controlled by signals from Head Office in Vancouver, which are transmitted by microwave to Ingledow substation, about 3 miles from the plant. Here signals are converted and continued by a single side band power line carrier system to the Port Mann plant.

THE INTEGRATION of a gas turbine plant into a predominantly hydro-electric system leads to substantial economic gains to the system as a whole.[1] The prime function of the plant is to stabilize the hydro system of the British Columbia Electric Company under adverse water conditions and merits further comment. The Company serves the southwestern area of the British Columbia Mainland and Vancouver Island including the cities of Vancouver and Victoria. The system has an installed hydroelectric capacity of 778,000 kw. Storage dams are filled during the summer months of low load and high run-off, and the winter loads are supplied mainly from storage. The hydroelectric energy available in a low water year may be as much as 350 million kwh. less than in an average year. If no other source of generation were available, the system would have to be engineered to provide reliability of service even in the most critical periods of water shortage. Thus at other times, excess water would be available which would either have to be split or used to generate secondary power saleable at very low rates. By "firming up" this secondary water power, a thermal plant can allow fuller utilization of the available water resources. It follows that during adverse water conditions, the plant will be operating at a high load factor, while at other times it will run at reduced output, or will be shut down altogether. Apart from firming up the hydro system, the plant also serves the following purposes:

1. To meet unforeseen peaks in the event of an unexpectedly high rate of load growth, and to serve as standby in case of forced or maintenance outage of any hydro or steam plant unit;
2. To serve as emergency source of power in the event of total system shutdown due to catastrophic outages of generating stations or transmission lines; to serve transportation, hospitals and other essential services under those conditions;
3. To provide power for starting up a future steam plant, now under construction.

Technical and Economic Advantages of a Gas Turbine Plant

For the functions described above, a gas turbine plant possesses a number of technical advantages over a conventional steam turbine plant. The units require only about 20 minutes from a cold start to full load as against 4 to 6 hours for the steam plant. Because of their basic simplicity, they lend themselves to automatic and remote control, obviating the need for operating labour. Gas turbines require a minimum of auxiliary equipment; they are compact and do not need heavy and elaborate foundations; they require considerably less cooling water than steam turbines, and the construction time is shorter.

These factors lead to generally lower capital and operating costs. The Port Mann gas turbine plant is estimated to cost 12.8 million or $128 per kw. exclusive of switchyard but including approximately $2.5 per kw. for remote and supervisory control. In contrast, a recent survey in the United States[2] indicates that steam turbine plant of the same 100 mw. capacity would have an average cost of $145 per kw. exclusive of switchyard, and automatic, unattended operation is not possible at present. It is estimated that operating and maintenance costs for an attended gas turbine plant will be 80% of those for a steam plant. For an unattended gas turbine plant this figure is reduced to 50% including the fixed charges for the additional investment in control equipment. Maintenance when required will be provided by mobile squads of servicemen.

The conventional re-heat steam turbine plant can be expected to give an overall thermal efficiency of about 30%, whereas the corresponding figure for a gas turbine plant is in the region of 22%. The resulting higher fuel costs are the main reason why gas turbine plants are not generally utilized for base load operation in a power system. However, when using thermal plants for stabilizing a hydro system a more favourable picture is presented. Such plants usually operate for only part of the year, and may be shut down altogether in some years. It follows that the long-term average load factor will be quite low, a figure of 15% being typical. On this basis, it has been estimated that gas turbines are more economical than steam turbines over a wide range of fuel costs ranging from 20c to 60c per million B.t.u.[3] since the higher fuel costs are more than offset by the lower capital charges, operating costs and maintenance costs.

Plant Location

The station is located at Port Mann on the south bank of the Fraser River approximately three miles east of the Pattulo Bridge. The site layout is shown in Fig.1.

The primary fuel is natural gas, supplied under an interruptible contract. On those occasions when the gas supply is cut off, the turbines will run on crude oil. The natural gas is supplied directly to the turbines through a 12 in. line fed from the 24 in. line immediately adjacent to the east property line. Crude oil is supplied via a 12 in. line from the Transmountain pipeline 1400 ft. west of the plant site to a dyked storage area enclosing a 100,000 barrel bulk storage tank, and a 24,000 gal. crude oil "day" tank. Within the storage area there is also a 24,000 gal. diesel oil tank for the stand-by generators which will be supplied by tank truck.

Cooling water is circulated from the river intake structure through two 42 in. steel pipes passing under the intervening Canadian National Railway marshalling yard. The switchyard is on the river side of the powerhouse and is connected by underground cables to the indoor switchgear. From the switchyard structure, transmission lines lead uphill, over the powerhouse, to the adjacent Horne Payne-Ingledow 230 kv. transmission line.

The outstanding advantages of the site from the viewpoint of accessibility

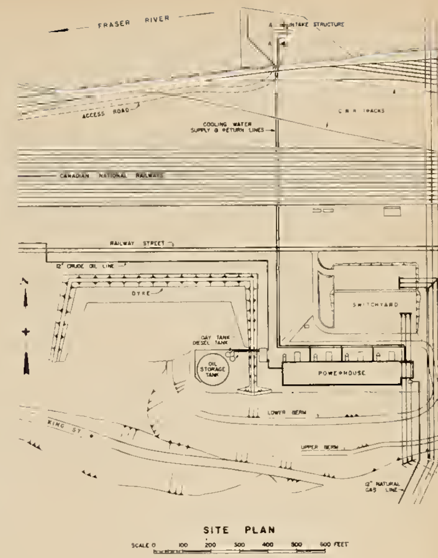


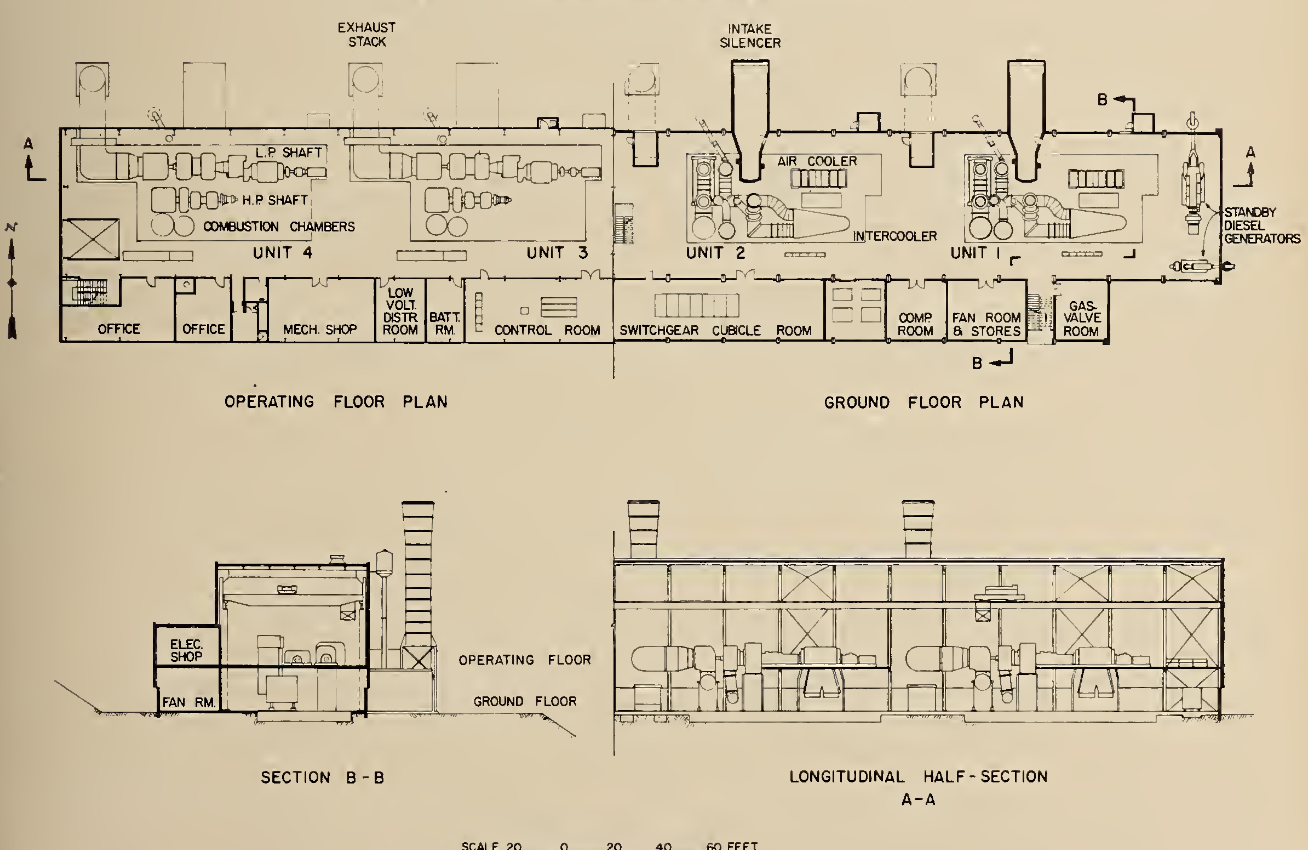
Fig. 1. Site plan

to fuel supply lines, cooling water and electrical transmission routes, outweighed the civil engineering problems introduced by the poor foundation condition.

Power House

The powerhouse is a steel framed structure of rigid bents. Considerable care has been taken in its design to ensure minimum sound transmissability by means of double skin cladding. The outer skin consists of

Fig. 2. Powerhouse general arrangement drawing



asbestos cement sheets on steel girts isolated for structural vibration by rubber insulators between girt and girt clips. The lathe and plaster inner skin is spring suspended to isolate air vibration.

As will be seen from the general arrangement drawing (Fig. 2.), the four gas turbine units are placed longitudinally in the power house to minimize the width of the structure and thus the excavation necessary to form the bench on which it is situated. Each unit is supported at operating floor level by an independent steel structure on independent foundation blocks. The operating floor around the unit is of reinforced concrete supported by a steel structure.

The Gas Turbine Units

All four machines are two stage, two shaft, reheat, intercooled, open cycle units, rated 25,000 kw. at 25° F air temperature and 21,600 kw. at 70°F. The greatly increased output at low ambient temperatures is particularly useful to meet the peak loads occuring during winter cold snaps. To utilize the increased output of the gas turbines under these conditions the 13.8 kv., 3,600 r.p.m. self ventilated turbo-generators are rated 30,000 kva. at 0.9 power factor.

It will be seen from the schematic diagram, (Fig. 3.) that the low pressure shaft comprises a turbine, compressor, generator, exciter and starting motor. The high pressure turbine, on the other hand, drives only a compressor and produces no electrical energy. For both high pressure and low pressure shafts, the air flow in the axial compressors and the gas flow in the turbines are in the same direction, and thus the end thrusts tend to compensate. Rigid couplings are provided between the compressors and the turbines, with flexible geared couplings between the other components. Fig. 4. shows one of the units in the course of erection.

The main air cycle can be followed on Fig. 3. Air is drawn in through sinusoidal silencers contained within the reinforced concrete air intake structure and enters the low pressure compressor. After partial compression it is re-cooled in the water intercooler, passes into the high pressure compressor and then into the high pressure combustion chamber where part of the total fuel charge is added. The hot gases are then expanded in the high pressure turbine and pass into the low pressure combustion chamber where more fuel is added. From the low pressure turbine the gasses are discharged through the exhaust stack to the atmosphere.

Each shaft is equipped with a gear-driven speed governor of the spring loaded centrifugal type. The governor of the low pressure shaft controls the load on the set. The speed of the high pressure shaft adjusts itself automatically to the load, and varies from about 3,600 r.p.m. at no-load to about 4,500 r.p.m. at full load.

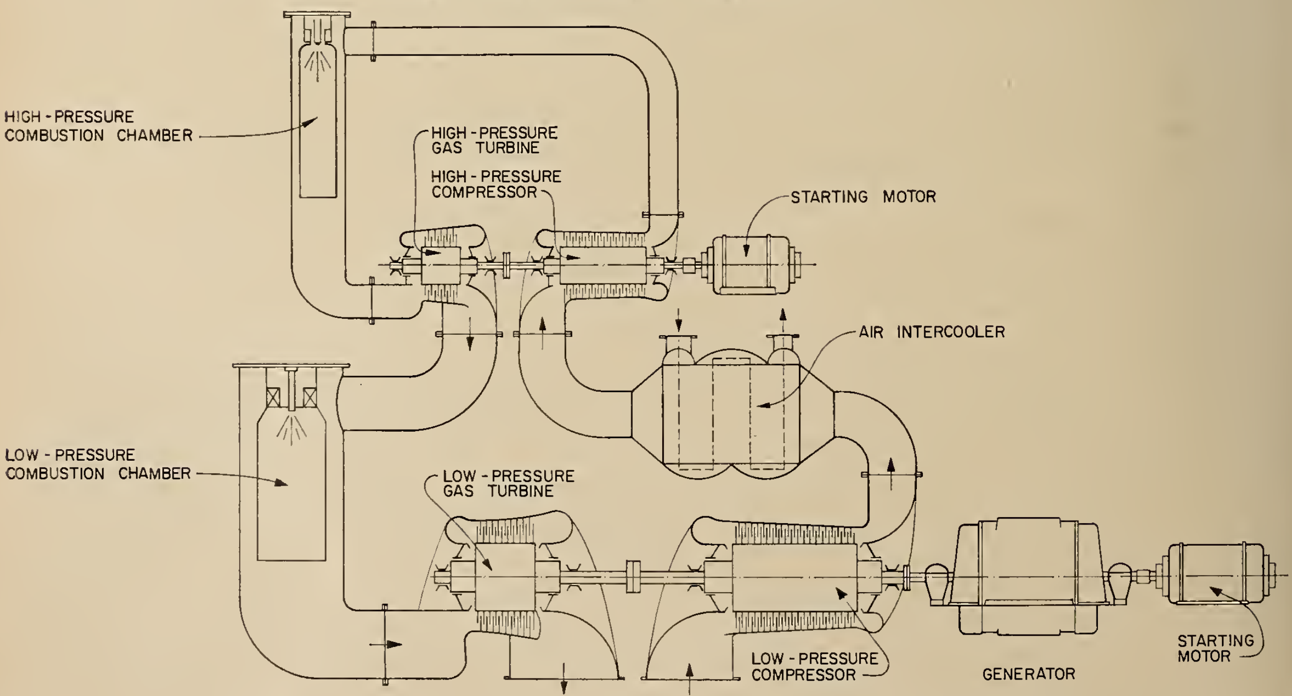
Cooling Water Supply

The plant requires 24,000 gal. of water per minute to cool the four gas turbine units. Considerable care was taken to ensure that no harm would be caused to the Fraser River salmon run by the use of this volume of water, and the intake and outlet structures were designed to comply with the requirements of the Department of Fisheries and the International Joint Salmon Commission in this regard.

Fig. 4. A gas turbine unit during erection

The final arrangement is shown in Fig. 5. The design provides for the installation of four 6,000 g.p.m. 200 h.p. vertical turbine pumps, mounted in four reinforced concrete cells submerged in the river, to supply water to the gas turbine plant through a 42 in. diam. steel pipe against a static head of 45.5 ft. The return line operat-

Fig. 3. Schematic diagram — gas turbine units



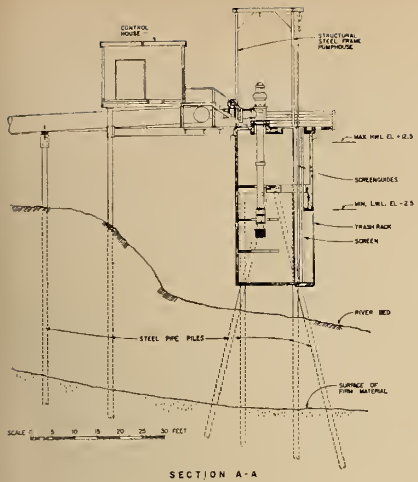


Fig. 5. Arrangement drawing of the cooling water intake structure

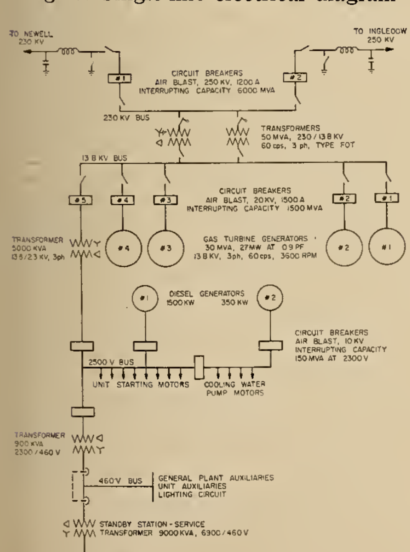
ing under gravity is of the same size as the supply line and returns the heated water into the river through a 48 in. diam. diffusing pipe 100 ft. downstream from the intakes.

Electric Features of the Plant

It will be seen from the single line electrical diagram (Fig. 6) that each generator connects through a 1500 mva. air blast circuit breaker to a single 13.8 kv. bus. Power is fed from this bus to the adjacent 230 kv. Horne Payne — Ingledow transmission line through two 50 mv. three phase type FOT step-up transformers and 1200 Amp., 6,000 mva. capacity air blast circuit breakers.

Station services are supplied by a 5,000 kva. 13,800/2,300 v. transformer with two diesel generating sets as standby. The provision of these diesel sets enables the plant to be started in case of a complete system shutdown, providing power for essential services, and for starting the new Burrard Thermal Generating Station now under construction. To maintain lighting and station services when the plant is shut down, power can also be fed to the 460 v. bus from a nearby 6900 v. distribution line.

Fig. 6. Single-line electrical diagram



Automatic Control

The plant is to be unattended, fully automatic, and will be controlled from the head office in Vancouver some 15 miles away. Signals from the Head Office are transmitted by microwave radio system to Ingledow Substation, 3 miles away. Here signals are converted and continue by a single side band power line carrier system to the Port Mann plant. Each unit can be completely controlled by the group of controls on the mimic diagram shown in Fig. 7.

To start the unit by remote control the turbine switch at the bottom of the mimic diagram is simply turned to the 'run' position. When this command is received by the supervisory equipment in Port Mann, it sends a signal back to the equipment in the Head Office. This causes the light in the centre of each switch to flash, indicating that the information has been received.

The impulse received at the station initiates all the operations required for starting the unit. The fuel and the cooling water valves are opened, the auxiliary motors are started, and the starting motors of the low pressure and high pressure shafts bring their stages to firing speed (approximately 30% synchronous speed) within about 4 minutes. Once the combustion chambers are fired, the gas turbine develops power and accelerates the set. Above firing speed, the power to the starting motors is cut off, but the starting motors continue to turn with their brushes lifted. When operating speed is reached the unit is automatically synchronized to the system, and the speed governor takes over. After execution of the command, another signal is sent back to the Head Office, and the light on the mimic diagram stops flashing, indicating that the required action has been completed.

Once the unit is on the line, load or voltage can be increased or decreased by pressing the appropriate 'raise' or 'lower' buttons alongside the mw. and mvar. meters. All the telemetering functions (mw., mvar. and kv.) are sampled on a cyclic basis and displayed continuously.

The plant is completely self-protecting. Although alarm indications are sent to the Head Office and are

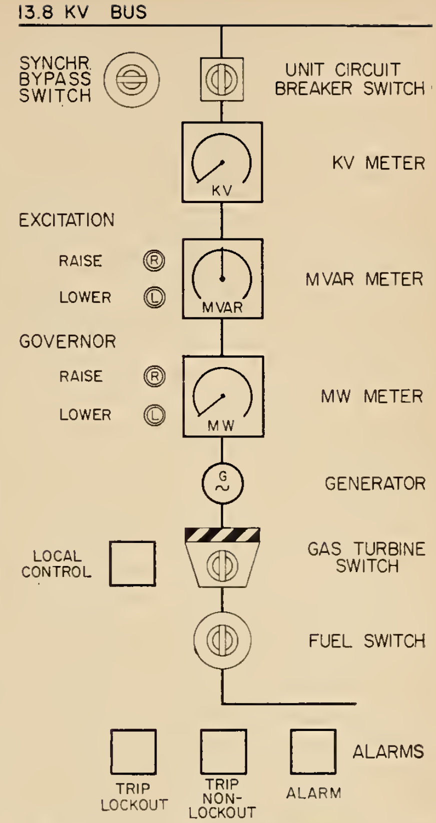


Fig. 7. Unit control panel mimic diagram

recorded by warning lamps on the control panel, the alarms are backed up by the necessary protective devices installed in the plant itself.

Conclusions

Gas turbine plants are now established as prime movers in the field of power generation. In an electric system such as that of the B.C. Electric Company, they can play a valuable part in improving the efficiency and economy of the system. Their relatively low capital cost and suitabiltiy for remote control makes them an attractive method of firming up the secondary power produced by a hydro-electric system, and they provide valuable standby capacity.

The Port Mann plan is of particular interest in that it is probably the largest gas turbine plant in the world, as well as the largest thermal power plant to be completely unattended and remotely operated.

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REMOTE CONTROL OF DUFFERIN FALLS GENERATING STATION

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Presented at the Engineering Institute of Canada Ottawa Regional Technical Conference, October, 1959

Dufferin Falls Generating Station is situated on the Lievre River within the limits of the Town of Buckingham, Quebec, three miles north of Masson, which is the operating centre of the Maclaren-Quebec Power Company and the site of The James Maclaren Company Limited Paper Mill. This is the third generating station on the Maclaren-Quebec Power Company's system and consists of two 22.5 mva., 85% power factor, 163.6 r.p.m. generating units which produce power at 13.2 kv. at the generator terminals. The power is transformed to 115 kv. for transmission to the Electric Reduction Company in Buckingham and to the Masson switching station where it is fed into the paper mill and interconnected with the Hydro Electric Power Commission of Ontario and the Gatineau Power Company. By means of a third winding on the transformer some power is transformed to 6,900 volts for transmission to the Town of Buckingham and to the station service. This latter feed is stepped down to 575 volts for distribution throughout the powerhouse. The generating units are coupled to variable pitch propeller type turbines rated 25,000 hp. and operating under a net head of 62 ft.

CAREFUL consideration must be given to the advantages and disadvantages for each particular application of remote operation of generating stations. One of the greatest advantages of supervisory control systems is in the matter of operating costs. Supervisory systems will eliminate the use of a complete set of operators, usually six to eight men, with an estimated saving in the region of $20,000 to $30,000 a year. Since the equipment for Dufferin Falls cost approximately $50,000 not including engineering, installation and maintenance, it will be appreciated that after a very few years this equipment will have paid for itself. Even more of a saving would result if Dufferin Falls had not been located in the centre of a built-up area and housing for the operators had to be provided. However, there are other advantages to remote supervisory control. It affords the means of centralizing many of the operations of a system from one central point. The operator has before him a complete picture of the system, and should anything go wrong, he can take the necessary action to rectify the situation without the necessity of passing orders over communication facilities to local operators. In addition, remotely controlled stations contain more efficient and additional protective devices which lead to the detection of any fault at an early stage and prevent serious trouble and damage from occurring.

Therefore, when remote supervisory schemes are planned, extra protective devices are installed to make sure that the operation of the station is independent of the operator's skill and vigilance. Any attended station can have this same degree of supervision, but because it is planned to have operators in attendance the complex protective devices are not usually provided, although there is a trend to make all stations fully automatic whether attended or not. Even with the most competent personnel available accidents or negligence may not entirely be avoided.

The disadvantages of remote supervisory control lie in the slightly increased capital cost of the station, but this in itself is only a very small percentage of the total cost of the station. As has been pointed out, this can be written off very quickly due to the saving in operating expense.

Another disadvantage which should be considered is that the feel of the station no longer exists for the operator. He can no longer see smoke coming from a generator, or hear the change in pitch of a generating unit as it comes up to speed. He must have complete confidence in and rely entirely on his supervision and indication equipment.

In some stations the loss of generating capacity even for a period of one-half to an hour may be quite serious. It may take at least this time or even more to get to the unattended station when major trouble is reported.

New schedules of testing, inspection and maintenance must be set up. These schedules which include visual as well as electrical and operating inspections must be carried out by competent personnel who should also be capable of operating the station manually in emergencies.

Supervisory control was therefore decided upon here because it afforded a real reduction in the cost of operating this station over a manually operated station and because the complete loss of generating capacity, if this should occur, would not be serious, since the station is operated with one unit shut down a large part of the time. The station being in a built-up area, there was no need to build housing for operators, and should anything go wrong, entrance to the station could be made very easily.

The Supervisory and Equipment at Dufferin Falls and Masson

(i) *Definition of Supervisory:* Supervisory control, as this remote control equipment for generating and terminal stations is commonly called, is defined as a means of transferring the control and supervision of a number of apparatus units from one location to any other location to which a single telegraphic channel can be established. Any kind of apparatus which can be controlled electrically is adaptable to supervisory control.

(ii) *Desirable Features:* However, before discussing the supervisory apparatus which is used at Dufferin, it would be well to enumerate briefly certain desirable features which the equipment should possess in order to be acceptable for use in operating a plant remotely. These features are:

1. The equipment should be extremely reliable. If it is not reliable then there is no point in operating the plant remotely.

2. The equipment should be simple in construction and should occupy a minimum of space. Relays, switches, pushbuttons should be of standard design and easily available if required for replacement purposes.

3. It should be flexible in design so that it may be mounted as part of the dummy bus arrangement or in any other manner which will facilitate operations. Usually a dummy bus ar-

rangement makes for easier operation.

4. It should require minimum maintenance.

5. It should not be possible to perform false operations due to unusual conditions, such as an induced voltage or any other interference on the telegraphic link.

6. The telegraphic link should require a minimum number of line wires and if operated over a carrier channel, should require a minimum of frequency space.

7. Individual indication should be provided to show the position for each major piece of apparatus.

8. It should be possible to extend the range of the equipment to include more apparatus using the same line wires or carrier equipment.

9. It should be possible to obtain remote telemetering indications without the use of an additional telegraphic link.

10. It should be extremely flexible so that it is able to be operated over carrier, or microwave channels as well as line wires.

11. It should be able to store information during loss of channel.

12. Important functions should take precedence over relatively unimportant functions during abnormal conditions.

(iii) *Description of Equipment:* The supervisory system used here is a D.C. pulse code, whereby operation of the selection button for a particular point automatically sends out a code of pulses assigned to that point. These pulses are registered on a relay counting chain at both stations with the result that the selection relay in question is operated at the slave station. When selection takes place, an identical code is sent back to the controlling station to check the selection. The equipment is then operated by a further code common to all points which initiates the operation required, such as closing a breaker. This system requires a channel of two wires and can also be operated over carrier channels. In this connection the D.C. pulse keys an audio tone generator for transmission over the carrier link.

There are five general classes of points, four of which are used in this installation. Those used are:—

1. *Supervision only of 2 conditions* — This type of point is used to indicate the position of circuit breakers and disconnect switches, to supervise alarm indications such as over-temperatures, high water, low pressure, etc., or to supervise the status of any device which can be in either of two positions.

2. *Control and Supervision* — This type of point is used to control and indicate position, an example being closing and tripping a breaker and supervising its position by red and green indicating lamps, or to start and stop generators, pumps, etc., with indication of whether the machine is running or stopped.

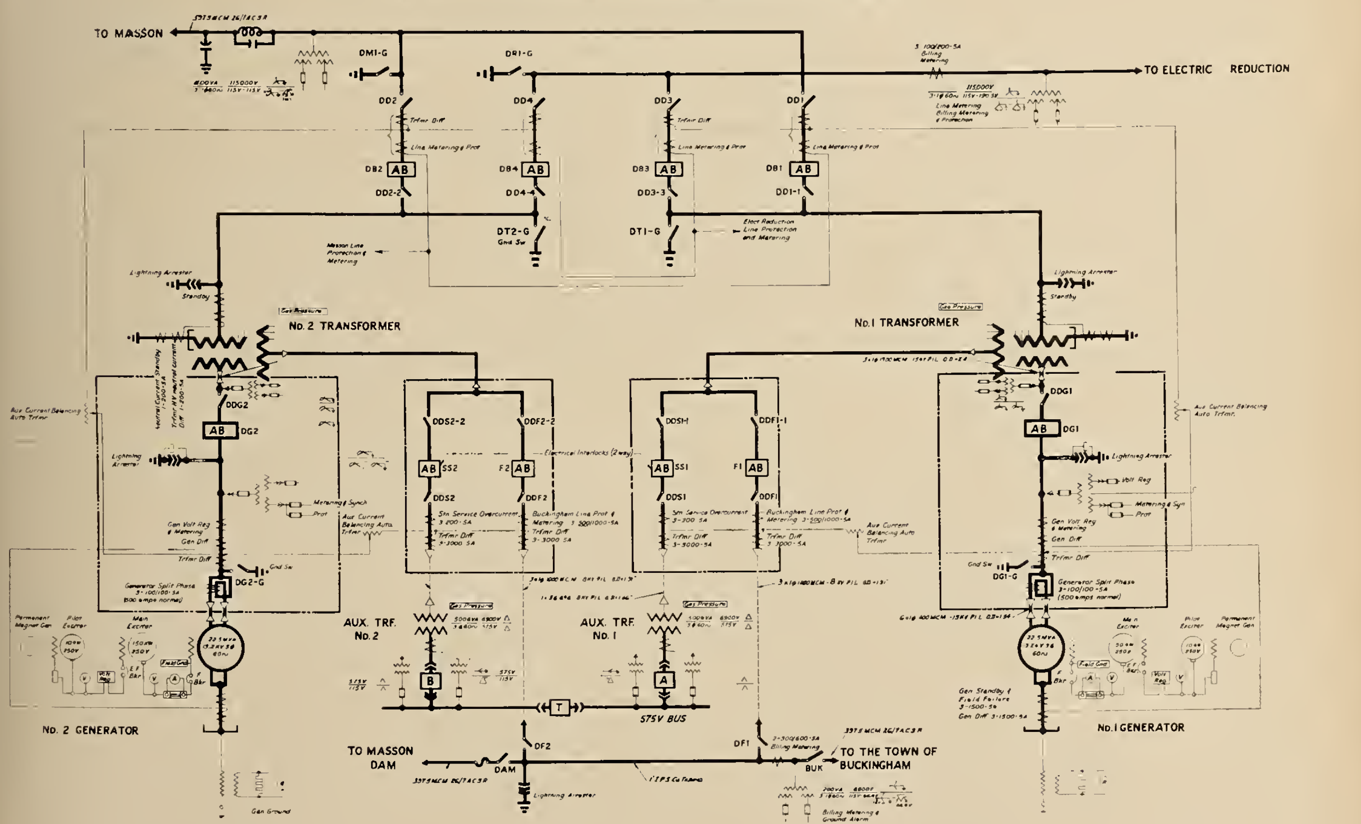
3. *Telemetering* — This type of point provides the means of obtaining a reading of a remote quantity on a telemetering receiver, for example, generator amperes.

4. *Control and Telemetering* — This type of point allows control of the quantity which is telemetered over that point, such as raising and lowering setting of tap changer with telemetering of tap position (or voltage), raising or lowering a gate with telemetering of gate position, raising and lowering the setting of a generator governor with telemetering of generator output, raising and lowering the setting of generator voltage regulator with telemetering of generator reactive loading.

The fifth type of point, which is control and supervision with telemetering, was not used in this installation. This is used to control, for instance, a circuit breaker, continuously indicate its position and also provide a telemetered quantity, such as current associated with the breaker.

In addition to these five points and their associated relays, there is common equipment at the master station, including an alarm bell and alarm lamp and a set of master control pushbuttons. These pushbuttons are common to all points and are

Fig. 1. Dufferin Falls Development Station Diagram.



operated after the point has been selected and have the following functions:—

(1) **Close** pushbutton key is used to operate the selected device to the close, start, or raise position as the case may be.

(ii) **Trip** pushbutton key is used to operate the selected device to the trip, stop, or lower position as the case may be.

((iii) **Check** pushbutton key is used to check the correctness of the lamp indications.

(iv) **Reset** pushbutton key is used to reset the control relays and restore the equipment to the normal at rest position at any time.

(v) **Alarm** pushbutton key is used to silence the alarm bell after an alarm indication has been received.

Other features which have been incorporated in the supervisory control are the scanning feature for the alarms and the master check. The scanning feature checks all alarm indications immediately after any alarm. The master-check checks the correctness of all lamp indications. This is particularly useful after restoration of lost battery power or lost channel facilities.

At Masson, which is the master station in the control of Dufferin Falls, a vertical cubicle is located in the control room on which is mounted a dummy bus arrangement of the Dufferin Falls Station. It is from here that all commands and intelligence to operate Dufferin Falls are made or received. Each piece of equipment at the remote station is controlled from an individual escutcheon plate containing indicating lamps and control selection buttons and mounted in the dummy buswork. The position of each piece of remote equipment is thereby indicated so that the operator at Masson knows at any given instant the condition at the slave station. The common equipment, as mentioned previously, and the alarm lamps and telemetering receivers are mounted above the dummy buswork. The control relays and wiring are mounted inside the cubicle.

At Dufferin Falls, the supervisory equipment consists of control relays, interposing relays and telemetering transmitters, which are mounted in a duplex switchboard similar to that supplied for the local automatic control and protection equipment.

Telemetering Equipment

Telemetering indication can be arranged to be received in conjunction with control points, or on separate points. An example of the former is the raising and lowering of turbine gate limit at the same time telemetering gate limit position. An example of the latter is telemetering generator reactive volt amperes. However, it must be pointed out that the type of telemetering transmitter used not only depends on the quantity being transmitted but also depends on the type of channel being used. Since a carrier is used at Dufferin, the impulse duration type of transmitter is used to provide the necessary keying. In the impulse duration system the measured quantity is proportional to the length of the pulse. The pulses are repeated at a constant rate.

Indications of all important metering quantities are obtained at the dispatcher's office. In most cases it is not necessary to have continuous indication of these quantities, so that each quantity is assigned a point of the supervisory and selected individually when required.

Mention might be made regarding the kilowatthour metering of the generators. These were placed on a selective point on the supervisory by the use of an impulse storage relay. The station kilowatthour meters are equipped with contact-making devices which provide a rate of impulse proportional to the kilowatthours. These impulses are then fed into a storage relay which stores the impulses until the operator selects the desired point. When the point is selected, the storage relay transmits all the stored impulses including any which are stored during this transmission. By proper selection of the contact device ratio, the number of impulses per kilowatthour can be chosen to suit the frequency of readings required by the operator.

Where continuous indication of a quantity is required, this quantity is telemetered over a separate channel so that it will not be interrupted by operation of the supervisory equipment. Continuous telemetering is provided for generator kilowatts and for Dufferin Falls headwater level.

The Transmitting and Receiving Equipment

In order to apply control to a generating station such as Dufferin Falls, such considerations as reliability, compactness of equipment, ease of operation and maintenance, etc., necessarily enter into any decision to choose a particular design. But more than that is required. The transmission and reception of commands and intelligence from one station to another must be considered. This equipment must not only be economical, but must also be compatible with the supervisory system being considered. Also the problem of voice communication and the type of line relay protection must be studied. This means considering all possibilities and combinations of possibilities before deciding on the complete system. Sometimes, it is possible to use one component from one manufacturer and some other components from another manufacturer to arrive at an economic and compatible scheme.

Types of Channel: There are three basic types of channel which could be used to provide the telegraphic link between the master station and the slave station. These are:—

(a) A pair of line wires. These can either be a pair or pairs of telephone line wires leased from a communication company or simply a multi-conductor cable installed and owned by the power company.

(b) Power line or telephone line carrier.

(c) Microwave.

The use of power line carrier: Power line carrier was decided as the telegraphic link between Masson and Dufferin Falls. The use of carrier resulted in an overall saving of approximately 15%, or $10,000, over a buried pilot wire cable. It may seem surprising that such a large saving was made using carrier. Most information on the subject suggests that in range of 3 to 5 miles it is a toss-up whether to use carrier or buried cable, and since the distance between Masson and Dufferin Falls is about 3½ miles, it would seem then that the two systems would be approximately the same cost. The reason for the difference lies in the fact that in this case, it would have been extremely costly to install the cable in the ground due to the rugged nature of the terrain between the two stations. It is suggested here that these rules-of-thumb be approached with extreme caution and should only be used as a guide and that all the factors of each situation be taken into account before a decision is made. Either type of channel was considered to be as reliable as the other, so the decision to use carrier was based purely on economic and technical factors.

Line Wires: The leasing of telephone circuits was not considered for three reasons, because of the number of channels required, because absolute reliability was required for at least two channels for protection purposes, and because it was felt better to have the transmission facilities under the control of the owners.

Microwave: Microwave was not considered too seriously because it was more expensive than carrier. The carrier equipment finally decided upon is a duplex, double side band, fixed frequency, amplitude modulated system with frequency shift.

The duplex feature is to provide communication facilities in both directions at the same time. The double side band section enables use of a full band width thereby eliminating the problem of crowding in the frequency range being used.

The carrier sends out a continuous fixed frequency which is modulated by means of audio tones keyed by the supervisory, telemetering, and relay protection equipment. Besides the transmitting and receiving equipment at each station, there are the capacitor coupling devices, wave traps, line tuning units and coaxial cable. This equipment connects the carrier sets to the H.V. transmission line at both stations, thereby completing the link for the reception and transmission of the communication, supervisory and telemetering signals to and from Masson and Dufferin Falls.

Each station is also provided with an emergency power supply for the carrier equipment in case of failure of the normal A.C. supply of the station. This supply is fed from an A.C. generator which is powered by a D.C. motor fed from the station battery. Condenser batteries are also supplied to maintain the plate voltages of the carrier equipment during switchover time from the normal to the emergency power supply.

The Remote Automatic Operation of the Generating Units

The basic station equipment used at Dufferin Falls is essentially the same as if it were being controlled manually with operators in attendance. There are, however, differences in the control equipment. Whereas in an attended station certain apparatus may be hand operated, these devices must all now be operated electrically and must be included as part of the control sequence. It is necessary to equip the station properly for automatic control in order to use as few supervisory points as possible and to prevent any serious damage from ever occurring to any piece of equipment.

Therefore, to do this, all the apparatus which must be operated automatically is equipped with control devices which can be electrically operated either directly through the supervisory or in response to some particular situation. These devices merely act as interlocks in the control circuit in the starting and stopping sequence of a generating unit. By this means each piece of apparatus is checked to see that it is in the correct position and in perfect running order. This meets our definition of an automatic generating unit which is one where the unit is started and synchronized automatically following a single impulse received from a control device. This impulse may be given by a local operator, by a remote operator through the supervisory control, or it may be initiated automatically.

There are other basic differences between attended and unattended stations. The problem is one of communication in the fullest meaning of the word. The operator at the remote station as we have explained before must rely entirely on the supervisory panel in front of him. His senses are useless to him. Therefore, in the design of such a station this must be kept in mind and everything done to help the operator overcome his position. For this reason the application of certain devices is different in unattended and attended stations.

At Dufferin Falls the protective features which shutdown the unit and lockout the unit are divided into two groups. In the first group the main field and main exciter field breakers and breakers of associated apparatus are opened immediately and the machine brought to a standstill as quickly as possible. In the second group the main field and main exciter field breakers are not tripped, but the generator breaker is tripped or opened when the unit passes through the speed-no-load position. The machine is then brought to a standstill as quickly as possible. The first group may be classed roughly as "electrical" faults, and the second group as "mechanical" faults. An example of the first group is generator differential protection. An example of the second group is generator overspeed (130%).

In considering the starting and stopping sequences at Dufferin Falls, it should be pointed out that these are typical of what is being done in most places in the automatic operation of generating units. Each installation should be studied on an individual basis however, because conditions vary from one plant to another.

In the starting up of the generators at Dufferin Falls from Masson over the supervisory, there are two distinct groups of equipment which must be in a definite position and working order before a unit can be synchronized on the line. The first group of equipment consists of the manually operated equipment such as hand reset relays, selector switches, hand operated breakers, etc. These devices must be set in position before leaving the unattended station. The second group of apparatus consists of equipment which must be running as a normal part of the everyday working equipment of a powerhouse. For example, the battery voltage must not be below a certain level, the air pressure for the generator brakes must be available, and cooling water must be circulating through the bearings. When these conditions are satisfied then it is possible, when the operator pushes the start button on the supervisory at Masson, to initiate the starting sequence of the generator. Pushing this button energizes the start-stop latching relay in the automatic equipment at Dufferin Falls, which in turn releases the brakes and energizes the master relay if all the interlocks are correctly set, and the auxiliary equipment is operating satisfactorily.

When the master relay is energized the governor solenoid is reset opening the turbine wicket gates and admitting water to the turbine. When the unit reaches 95% of rated speed, the voltage matcher and the auto-synchronizing equipment are connected. The voltage matcher matches the machine voltage to the line voltage, the auto-synchronizer adjusts the speed of the machine to match the system frequency. When the two voltages are matched and the two speeds are in synchronism, the generator breaker is closed. This connects the machine to the system. Once this is done the loading, excitation and gate limit can be adjusted as required.

Normal stopping of the generator is initiated by a stop impulse which de-energizes the master relay. This in turn energizes the governor shutdown solenoid, closing the turbine gates. When the gates approach the no-load position, the gate limit switch closes and trips the generator breakers. As the unit drops below a certain speed, a speed switch closes which initiates the application of brakes, first intermittently and then continuously. All devices will then return to the normal starting position.

It is evident from the above that the successful operation of an unattended station depends on the inclusion of extra control devices which limit the number of points on the supervisory control equipment, prevent the false operations, and detect early any faulty conditions. The starting and stopping of each generator at Dufferin Falls requires only one point on the supervisory.

Other Automatic Features

It is not enough to have the generating units operated remotely in an unattended location without considering the varied auxiliary equipment and its relation to the automatic operation of the Units. So it might be of interest to note some of the other features which were especially considered in view of the fact that this station is unattended.

(i) *The 575 Volt Auxiliaries:* There are two circuits to the 575 v. auxiliary equipment. Great flexibility is obtained as a result. These circuits are fed from the tertiary windings of the main transformers at 6900 v. to 500 kva. auxiliary transformers where the voltage is stepped down to 575 v.

If voltage should fail on one unit for any reason the equipment immediately detects this condition and will transfer over to the other source. This transfer contains a time delay feature, which had to be taken into account when supervision features were added to some of the auxiliaries. These had to be further time delayed to take care of the time delay of the transfer.

The time of the transfer from one feed to the other is in the order of two seconds. This is well above the time most authorities give as being necessary to make the transfer. If the transition time is too short, the residual voltage on the motors which can be 180° out of phase with the other source may cause excessive currents to flow in the motor windings when they are connected to the other source. No trouble was experienced from any motor equipment and especially the 50 hp. governor oil pump motor when a transfer was made. No attempt was made to determine the optimum time required for a transfer.

It was also necessary that each feeder breaker, which is the no-fuz type, be supplied with an auxiliary switch which would sound an alarm should it open under any abnormal condition, since equipment such as the governor oil pumps, transformer oil coolers, fire pump, compressors, etc., must be available for operating at all times.

(ii) *Fuses vs Circuit Breakers:* As well as the 575 volt auxiliaries operating at all times, it was necessary that there be no interruption in the D.C. control circuits. To prevent any loss of D.C., no-fuz circuit breakers were substituted for fuses as much as possible. Each circuit breaker has an auxiliary switch which sounds an alarm should the breaker open for any reason whatsoever.

(iii) *Governor Bypass Solenoid:* Due to the wide variation in the loads and the operating conditions experienced at Dufferin, it was necessary that the operation of the governor bypass solenoid on the units be automatic to meet these changing conditions.

(iv) *Braking:* The braking on the machines is so devised that on shutdown when the speed has dropped to 50% rated speed, and if the gates are closed, and the generator breaker has opened, a cycle of intermittent on-off braking will be applied to the machine, when the braking will be applied continuously. The circuit is devised so that the braking solenoid will be energized as long as the machine is shutdown. This is an operating policy. If anything should happen to the D.C. circuit, the creep detector will guard against any movement of the unit. A standby braking scheme is also applied to these units as back-up feature to the main braking. As has been mentioned, in the event of an electrical fault of any kind it is imperative that the machine be brought to rest in case fire has resulted, which would only be fanned if the machine is allowed to rotate. This standby braking is timed to operate a few seconds after the continuous application of the primary braking.

(v) *Creep Detection:* Damage to generator bearings will result if the unit is allowed to rotate at very low speeds for even a short time. This condition is likely to appear on shutdown if for some reason the brakes do not hold or do not stop the unit quickly enough when the low speed range of about 20 r.p.m. or below is reached. In order to guard against this, detectors are installed which will operate if the machine is not brought to rest within a certain time after the unit shutdown relay is deenergized. If the shutdown takes too long, then the operation of the creep detector will result in the machine starting up automatically and resynchronizing. If the shutdown is due to lockout, then the headgates are dropped.

(vi) *Shearpin Failure Alarm:* Shearpins in the gate mechanism of hydroelectric units from time to time fail because a stray log or foreign matter has lodged in the turbine wicket gates. This condition may prevent the shutdown of the generating units and may set up excessive vibrations in the powerhouse at certain loads. At Dufferin when the units were being installed the failure of a shearpin when the machine was running at 80% gate opening set up a very serious vibration which for all intents and purposes, vanished when the machine was brought down to speed-no-load. As a result of this situation, a shearpin failure alarm scheme is installed which automatically brings the machines down to speed-no-load and sounds an alarm at Masson. The scheme installed consists of tying all the gates together by means of a cable. Thus, if one gate is out of line a plug will pull open which operates the control features mentioned above.

(vii) *Alarm Panel:* The alarm panel at Dufferin Falls contains approximately ninety points and is divided into three groups, one for each unit and one for general station alarms. Not all the alarms brought to this panel are taken back to Masson. The whole matter of effective communication between the situation at Dufferin Falls and the operator at Masson centres around this alarm panel. It is not necessary for each alarm point to be taken back to Masson, but at the same time, it is necessary that the operator at Masson know whenever some faulty condition shows up. Therefore, alarms of a very serious nature are brought back on an individual basis. An example of this is the creep detector alarm.

Alarms of a less serious nature, such as turbine bearing temperature high, turbine oil level low, etc., are combined to form one alarm at Masson called the "unit miscellaneous alarm". For these alarms it is necessary for the operator at Masson to go immediately to the alarm panel at Dufferin Falls where he can identify the specific piece of apparatus involved. It will be seen here that the operator should be prepared for trouble on any of the equipment covered by this particular common alarm. Then there are alarms which are of a less serious nature still, such as battery low voltage, 575 v. bus ground, breaker no heat, etc., which are grouped together to form what is called "general station alarm." The seal-in features have been removed from some of these alarms in this group because they may come on regularly and the condition subsequently rectifies itself. The operator merely checks this group to see if it can be reset; if not he can wait for a convenient time before making a trip to Dufferin Falls station.

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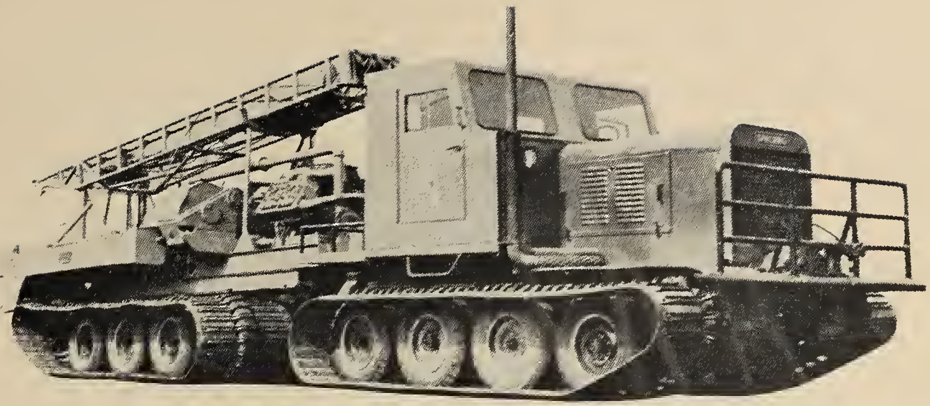

VEHICLES IN MUSKEG

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Muskeg is no longer an unknown material. An orderly classification of muskeg types has provided a basis for determining its physical and mechanical properties. In turn, these properties have been applied to the design of structures and vehicles suited to application in muskeg. It is now possible to treat muskeg as a known engineering material. The design and application of muskeg vehicles are used to illustrate the validity of the current muskeg technology.

TO DEVELOP northern Canada it is necessary to traverse muskeg. Many popular articles have been written which leave the reader with the impression that muskeg is a nebulous substance. It has even been endowed with the human ability to plot for the frustration of engineers and construction crews. The general result of such articles has been to rouse management reticence toward any field operations involving muskeg.

It is the intent of this paper, through the use of previously published data, to show that muskeg, far from being a mysterious, ever-changing substance, is in fact a well known engineering material. Muskeg has been defined and classified. Its physical properties have been listed and explained. A few measurements of some of the mechanical properties of muskeg have been made and applied. The known characteristics have served as the design basis for successful engineering structures founded on muskeg. They have also been applied to the design of successful vehicles for use in muskeg.

Vehicle design is used as the illustration of the status of the applicability of current muskeg technology.

TABLE I

Summary of Properties Designating Nine Pure Coverage Classes

Coverage Type (Class)	*Woodiness vs. Non-Woodiness*	*Stature (Approx. Height)*	*Texture (Where Req'd)*	*Growth Habit*	*Example*
A	Woody	15 ft. or over	—	Tree form	Spruce, larch
B	Woody	5 to 15 ft.	—	Young or dwarfed tree or bush	Spruce, larch, willow, birch
C	Non-woody	2 to 5 ft.	—	Tall grass-like	Grasses
D	Woody	2 to 5 ft.	—	Tall shrub or very dwarfed tree	Willow, birch, labrador tea
E	Woody	Up to 2 ft.	—	Low shrub	Blueberry, laurel
F	Non-woody	Up to 2 ft.	—	Mats, clumps or patches sometimes touching	Sedges, grasses
G	Non-woody	Up to 2 ft.	—	Singly or loose association	Orchid pitcher plant
H	Non-woody	Up to 4 in.	Leathery to crisp	Mostly continuous mats	Lichens
I	Non-woody	Up to 4 in.	Soft or velvety	Often continuous mats, sometimes in hummocks	Mosses

Classification and Occurrence of Muskeg

The word *Muskeg* is ascribed almost as many meanings as there are people using the term. The name has been applied to swamps, peat-beds, forest floors and tundra, to list a few. It is not properly applied to any of these, although some of the items listed are components of muskeg.

Briefly, the term muskeg designates organic terrain. The physical condition of organic terrain is governed and modified by the structure of the contained peat, the living surface vegetation, the mineral sublayer and topography. Radforth[1] has written convincingly that each of the four named condition factors are essential to any discussion or assessment of muskeg. Each must then be included in the definition. In addition to physical characteristics, muskeg has a dimensional property. Depending on the problem being investigated, it may be linear, areal, or cubic.

To a practical degree the class of living coverage describes the origin of the fossil material (peat) beneath it. Also, the coverage classification is a primary indication of the relative magnitude of the mechanical properties of a muskeg. For some purposes, noteably tracked vehicle operations, the implicit estimates of mechanical properties made from this classification suffice.

The nine pure coverage classes used by Radforth[2] to describe muskeg are shown in Table 1. Note that these classes require only observation of stature, degree of woodiness, and, in a few cases, texture. No knowledge of species is required or even desirable for engineering purposes. Only classes which represent 25% or more of the coverage are reported. Thus, a muskeg can be described by one, two or three letters referring to coverage classes. In practice, a fourth letter is never justified.

Topographic features listed by Radforth[2] are shown in Table 2. The 16 contour types have been consolidated into four major groups. This simplification is made on the basis of vehicle response to the contour types being roughly constant within any one of the coarser groups.

Subsurface constitution becomes important in some operations. Radforth's[3] 16-part classification of this muskeg feature is given in Table 3. Again, a simplified grouping, listed as "predominant characteristic" in this tabulation, suffices for vehicle purposes. Usually, only the degree of fibrosity which will be available to the vehicle after failure of the living mat will be of interest.

Figs. 1-5 inclusive, show some of the commonly occurring coverage classifications. All muskegs, even although only a few inches deep are impassable to wheeled vehicles. Of the types shown, only the muskeg of Fig. 1. could be traversed by a conventional tractor with a "bush" track. All of these can be crossed with special muskeg vehicles. Only the muskeg shown in Fig. 5. would require deviation from a straight line traverse to avoid weaker sections of mat.

Fig. 1. Type BDI Muskeg. The "B" element has been removed where the men are standing but may be seen in the background.

Fig. 2. Types FI, BFI and AI Muskeg. (a) FI. (b) BFI: "B" may be recently encouraged by action of the "swampy" ditch in foreground. (c) AI: This can be traversed by high ground pressure tracked vehicles except if it is underlain by wet, remouldable clay.

Mathematically, a very large number of combinations of the nine pure coverage classifications are possible. Of these, Radforth considers only 25 occur commonly. The five examples referred to above are typical of muskegs which had to be avoided in vehicle operations until quite recently. It does not follow that these are the only muskeg types resulting in mobility failures, nor that they are the most notorious causes.

Being able to classify muskeg, although essential, is strictly a passive art. The next and probably most important step is to decide what to do about the organic terrain in any given case. At this point the general and the specific extent of muskeg becomes important.

It is generally accepted that at least 320 million acres of Canada are muskeg covered. In this vast area, characterized by low bearing and shear strengths, engineering structures are rare and costly. Access has, until recently, been almost restricted to air and water travel. The few trails, roads and railroads which do traverse muskeg were extremely costly to construct. Except for a few very recent examples these ground access routes are very costly to maintain. Footings for buildings and machinery usually require total excavation of the peat. Temporary structures can be and are built on footings founded on shallow clay pads which in turn are floated on the muskeg mat. These floating pads are often successful under quite heavy structures. The economic advantages of the clay pad over deep excavations are obvious.

Economic Significance of Muskeg to One Industry

The Gordon Report to the Government of Canada noted that difficulty

Fig. 3. Type FHI Muskeg. The strips of "D" form less than 25% of coverage and so are not reported. However, an experienced driver would straddle the D coverage if proceeding in that direction.

Fig. 4. Type HFI Muskeg. Note "D" coverage in background and slight hummocking in foreground. The hummocks dictate a deep, soft vehicle suspension for early spring operations.

Fig. 5. Type FI Muskeg. Bare surface in the foreground is the result of mat damage by vehicles. Detailed route selection would be desirable over this muskeg.

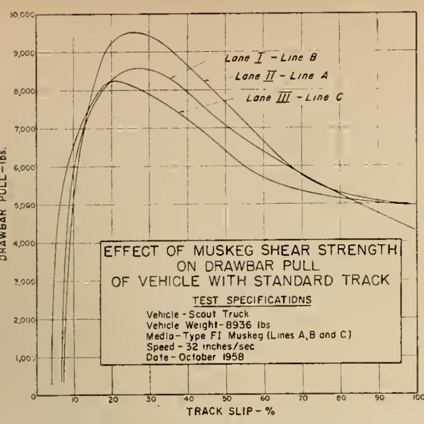

Fig. 6. Effect of Muskeg Sheer Strength on Drawbar Pull of Vehicle with Standard Track.

of access is hampering development of the northlands. Muskeg is the most prevalent single item contributing to the noted difficulty of access.

About 125 million acres of the 500 million acre Western Sedimentary Basin are muskeg covered. Therefore, the oil industry may ultimately conduct up to 25% of its exploration and development program in muskeg. Obviously then, this is one industry which must take the added cost of muskeg operations into all of its economic calculations. Further, it must substantially reduce the cost of one-quarter of its exploration and exploitation programs if crude oil from muskeg areas is to be competitive with that from other areas.

Since 1947, the industry has cut an estimated 180,000 miles of trails to facilitate exploration. Geophysical crews have continuously profiled over 250,000 miles on those trails at a probable cost of $150 million. After the geophysical work, a deep test well is often drilled. In muskeg areas these tests cost about two and one-half times as much as those of similar depth at plains locations. The transportation costs alone for a deep test hole in muskeg areas has reached $300,000 or about 30% of the total cost.

The Pembina oilfield, one of the largest in area in North America, has provided some interesting cost figures. Walsh[4] has stated that the capital investment in the Pembina field will be greater than in the St. Lawrence Seaway, excluding the power development. Hemstock[5] estimates the final exploitation cost in Pembina at $415,900,000. Of this amount, he attributes $25 to $30 million directly to muskeg.

From this rather cursory glance at the effect of muskeg on the economics of one industry, it is obvious that here is a field worthy of concerted engineering effort. Indeed, much of the development of northern Canada's natural resources is already hampered by lack of engineering data on muskeg. Activity in muskeg research and engineering is increasing and, happily, the problem is yielding in proportion to these efforts. There are many phases yet to be studied, however.

Transportation in Muskeg Areas

Transportation through muskeg is a frequently recurring problem of some notoriety. There are at least four major approaches to the solution of transportation problems over organic terrain. The method selected will depend on the particular problem and economics involved. The four systems are:

1. Build roads of a class suitable to the type and quantity of traffic to be carried;
2. Build temporary roads or tractor trails over frozen muskeg and restrict operations to the winter season;
3. Air or water-lift materials; or
4. Construct special tracked vehicles for operation in muskeg at all seasons without roads.

The first two of these methods have been the most common solutions attempted.

Various road building techniques are used and various results achieved. The cost is always high. The degree to which the technology of road building over muskeg has advanced is well illustrated in a recent paper by Brawner.[6] His paper details the application of the preconsolidation principle to a muskeg subgrade for a 4-lane highway. Obviously, this technique is only applicable to high density, long duration traffic. Short term access roads over muskeg are more simply constructed but may, in view of the limited tonnage to be transported, still be prohibitively costly.

The winter-cleared frozen muskeg trail is a crude form of road. Muskeg type and the construction effort expended will determine whether the trail is suitable for wheeled or tracked traffic. In the case of hummocked type "FI" muskeg, a smooth surface suitable for high speed wheeled vehicles is produced only at great cost. If the roots of type "A" trees must be removed construction costs will also be high. In both of these examples road-bed life will be short since sections of the road will be without a surface mat to protect the frozen peat and to help support the load. If a longer road life is required only minimum preparation of the trail should be undertaken. For example, trees should be cut rather than bulldozed and hummocks should not be cut off. Traffic will then be restricted to tracked vehicles operating at less than their already low maximum speed. Obviously, the winter trail system, although very common, is not entirely satisfactory. In one case, high speed traffic can be sustained for 2 to 3 months; in the other, tractor trains can be operated at 2 to 3 m.p.h. for 3 to 4 months. Even the longer of these periods is not adequate for economical exploitation of natural resources.

A winter tractor trail across type "FI" muskeg costs about $200 per mile. If, for example, a 600 ton oil drilling rig is transported in and out by truck the road charge is $1.20 per ton mile. If drilling is not finished in time to retrieve the rig before the spring breakup the road cost jumps to $2.40 per ton mile.

Air and water transportation are outside the scope of this paper. These two methods cannot, however, be ignored when choosing a transportation system for muskeg areas. In some cases it will be found that aircraft or boats will provide more economical transportation than vehicles. In only rare cases will either form eliminate the requirement for vehicles at both ends of the route.

With minor limitations, special purpose tracked vehicles permit access to muskeg areas in all seasons. With the few types available until recently, payloads were restricted to less than 5 tons per vehicle. Although in the last year the load capability of muskeg vehicles has increased to 20 tons, most development activity has been in the 1 to 10 ton class which meets the bulk carrier requirements of a

Fig. 7. Test Lane layout Oct. 1958 Vehicle Trials.

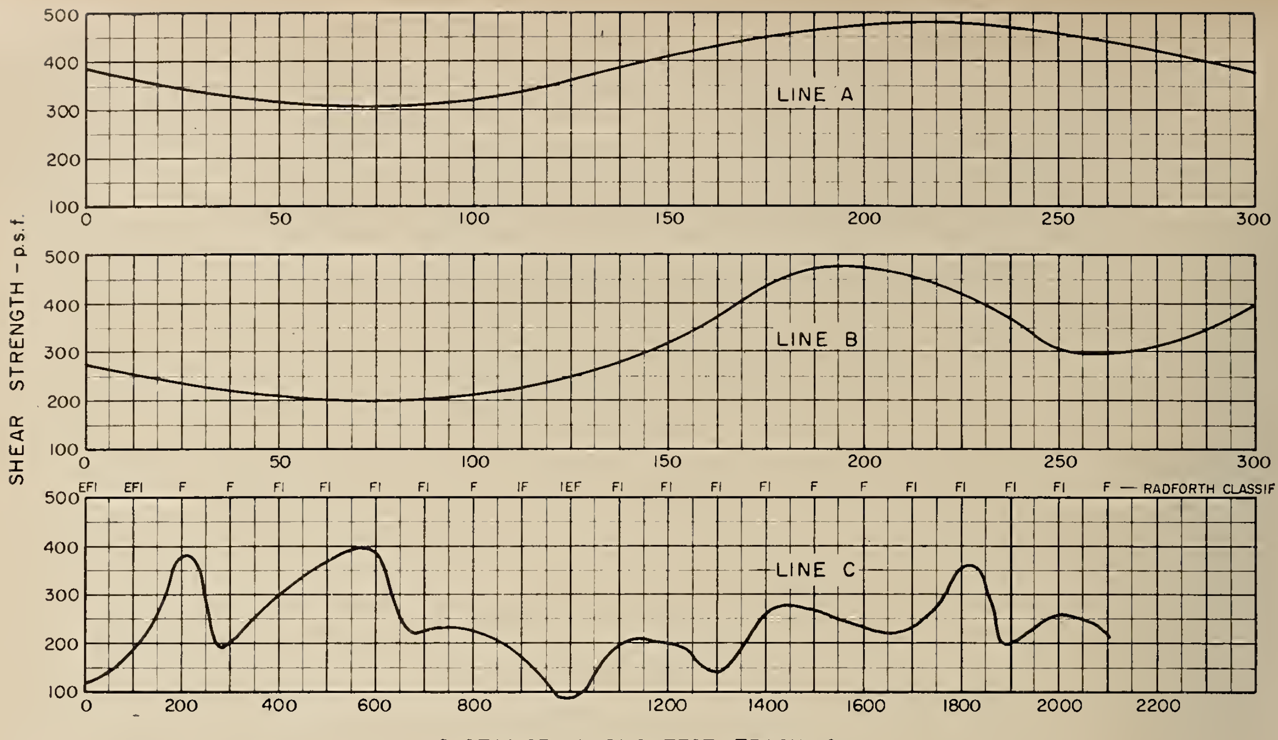

Fig. 8. Comparison of Undisturbed Shear Strength for Three Lines (Note: All data shown for 6 in. depth.)

broad spectrum of industries. A prototype 20 ton payload machine has recently been put into service to meet a special load requirement of the oil industry.

The economics of tracked vehicle operation in muskeg have not yet been well established. Development of the vehicles is being carried on while the machines are in field service. Thus it is difficult to separate the operating and development costs. However, at this time it is estimated that tracked transportation machines can be operated for $1 to $2 per ton mile. The high cost can be justified only when road construction costs can be avoided or when access at a particular time is worth a premium. For comparison, rail freight rates average 5c per ton mile and truck rates vary from 5c to 20c per ton mile on highways, and from 20c to 50c per ton mile exclusive of road costs on winter roads. A summer road over muskeg to a wildcat site will cost from $2,000 to $12,000 per mile and will be abandoned after 1200 tons have been moved over it. The road charge is then $1.60 to $10 per ton mile and the total cost $1.80 to $10.50 per ton mile.

Mechanical Properties of Muskeg

The progress made in the last 12 years in classifying muskeg is now being supplemented by investigations of mechanical properties. Fairly extensive work has been carried out in the fields of foundations and road construction in muskeg. In 1957, the determination of the mechanical properties of muskeg relative to vehicle performance[7] was started. This work was continued in 1958 and a correlation between muskeg shear strength and net vehicle performance was tentatively established.[8]

The test method used for the vehicle test programs in muskeg was adopted from vehicle tests in mineral soils and in snow. The method, known as the "Pull-Slip" test, has been described in detail in earlier publications. These tests are made with the test vehicle tracks rotating at constant velocity. The speed of the test vehicle, and therefore the slip rate of its tracks, is then varied in increments by changing the rate of advance of a dynamometer vehicle coupled behind. A strain gauged drawbar, included in the tow line between the test and dynamometer vehicle, measures the force required to maintain these imposed lower speeds of the test vehicle. Sprocket speed pick-ups on the test vehicle and a fifth wheel towed behind the dynamometer vehicle provide the data necessary to calculate track slippage. From these data, recorded on a common time base, a pull-slip curve is prepared.

Typical results of this type of test are illustrated in Fig. 6. The particular curves shown are from three lanes, Fig. 7, of varying shear strength, Fig. 8, as determined by a hand-operated shear vane. These three figures and Fig. 9 are treated in detail in a previous publication.[8]

Two separate results are presented in Fig. 9. It will be seen from the two dotted lines that a measureable decrease in performance results from progressive deterioration of the muskeg mat. Later checks revealed that some change, which cannot yet be quantitatively specified, occurred at depth in the muskeg. The correlation between experimental and calculated performance shown by the two solid lines is based on vane shear strength of the surface mat. The difference of numerical values between these two lines is satisfactorily accounted for by external motion resistance. This correlation is treated in detail in an earlier report.[8]

In summary, it has been shown from vehicle test programs[7, 8] that:

1. Vehicle performance is sensitive to the condition of the surface layers of the muskeg at the time of the test. Performance variations from this source were found to be as great as 12%. Repeated passes can result in 15% or more reduction in performance before rupture of the mat commences.

2. Vehicle geometry is the design feature which most affects mobility performance in muskeg. Such features as longitudinal location of the dynamic centre of gravity, belly width, track contact pressure, and grouser spacing can be mutually optimised. Optimum design will result in higher net traction on muskeg than

can be obtained from rubber tired all-wheel drive vehicles on dry concrete pavement.

3. The shear vane produces a strength profile which is compatible with the vehicle pull-slip curve. This instrument also shows that there is not an exclusive shear strength associated with a specific muskeg classification. The instrument could probably determine the range of shear strengths to be expected in various muskeg types. These data could be used, perhaps empirically, to specify which of a group of vehicles could negotiate a chosen route.

4. Generally, the results of the vehicle test programs support the contention that muskeg mechanics is within the realm of classical soil mechanics. For example, the vehicle performance curves are of the same shape obtained for tracked vehicles operating in sand, clay and snow. It has also been shown possible to predict the effect on a vehicle operating in muskeg of a design change based on experience gained with other vehicles in mineral soils.

Muskeg Vehicle Design

A valid system of muskeg classification was essential to the orderly determination of the mechanical properties of muskeg. In turn, the mechanical properties had to be established as a basis for vehicle tests. Data on the mechanical properties of muskeg and the vehicle response to variations in those properties are directly applicable to vehicle design. It is believed that some data meeting this requirement have been produced and are ready for broad application.

From the results of the test programs, it is obvious that important improvements can be made in current vehicles. Some of the modifications suggested by the test results are now being incorporated by both manufacturing and operating companies. Possibly the most important result obtained and applying to conventional tracked vehicles is that concerned with permissible ground pressure. It has been shown[7] that if the nominal ground pressure truly reflects the unit ground pressure over the entire track contact area the arbitrarily imposed 2 p.s.i. limit can be raised to between 3 and 5 p.s.i. in Type FI muskeg. Thus, a vehicle can be built stronger and with a little less attention to weight. The latter will usually reduce costs.

The results of the test programs have also indicated that there is a limit to the mobility which can be achieved with a practical, conventional tracked vehicle. For example, the test vehicles used and others in regular field use all trim nose high. This trim characteristic is most pronounced in short vehicles which are tail heavy. Increasing the track contact length and moving the centre of gravity forward reduce the trim angle and, as shown earlier,[7] substantially increase the drawbar coefficient. However, in a vehicle steered by any of the methods which impose a speed differential on the two tracks the ratio of length to tread must not be greater than 1.8/1 and preferably not greater than 1.6/1. Therefore contact length cannot be increased indiscriminately or trail, highway and railroad width limitations will be exceeded. The most effective way of advancing the longitudinal position of the centre of gravity is to move the engine and transmission forward.

Fig. 9. Effect on Drawbar Pull of Doubling Track Pitch.

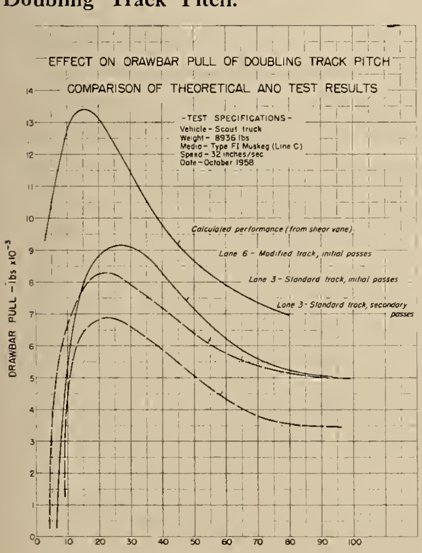

Fig. 10. Musk-Ox 20 Ton Articulated Transporter.

TABLE II
Topographic Features

Simplified Grouping	*Contour Type*	*Feature*	*Description*
	A	Hummock	Includes tussock and nigger-head, has tufted top usually vertical sides, occurring in patches, several to numerous
I.	B	Mound	Rounded top, often elliptic or crescent-shaped in plane view
	C	Ridge	Similar to mound but extended, often irregular and numerous; vegetation often coarser on one side
	D	Rock gravel plain	Extensive exposed areas
	E	Gravel bar	Eskers and old beaches
II.	F	Rock enclosure	Grouped boulders overgrown with organic deposit
	G	Exposed boulder	Visible boulders interrupting organic deposit
	H	Hidden boulder	Single boulder overgrown with organic deposit
	I	Peat plateau (even)	Usually extensive and involving sudden elevation
	J	Peat plateau (irregular)	Often wooded, localized and much contorted
III.	O	Free polygon	Forming a rimmed depression
	P	Joined polygon	Formed by a system of banked clefts in the organic deposit
	K	Closed pond	Filled with organic debris, often with living coverage
	L	Open pond	Water rises above organic debris
IV.	M	Pond or lake margin (abrupt)	
	N	Pond or lake margin (sloped)	

TABLE III
Subsurface Constitution

Predominant Characteristic	*Category*	*Name*
	1.	Amorphous-granular peat
	2.	Non-woody, fine-fibrous peat
Amorphous-granular	3.	Amorphous-granular peat containing non-woody fine fibres
	4.	Amorphous-granular peat containing woody fine fibres
	5.	Peat, predominantly amorphous-granular, containing non-woody fine fibres, held in a woody, fine-fibrous framework
	6.	Peat, predominantly amorphous-granular containing woody fine fibres, held in a woody, coarse-fibrous framework
	7.	Alternate layering of non-woody, fine-fibrous peat and amorphous-granular peat containing non-woody fine fibres
Fine-fibrous	8.	Non-woody, fine-fibrous peat containing a mound of coarse fibres
	9.	Woody, fine-fibrous peat held in a woody, coarse-fibrous framework
	10.	Woody particles held in non-woody, fine-fibrous peat
	11.	Woody and non-woody particles held in fine-fibrous peat
Coarse-fibrous	12.	Woody, coarse-fibrous peat
	13.	Coarse fibres criss-crossing fine-fibrous peat
	14.	Non-woody and woody fine-fibrous peat held in a coarse-fibrous framework
	15.	Woody mesh of fibres and particles enclosing amorphous-granular peat containing fine fibres
	16.	Woody, coarse-fibrous peat containing scattered woody chunks

However, if the engine protrudes far ahead of the tracks the obstacle crossing ability of the vehicle will be impaired. To achieve the mobility increase known to be available from these two sources the morphology must be revised.

The desired increase in contact length and location of the centre of gravity can be achieved with articulated vehicles. The first vehicle in which joint-force-steered articulation was applied to muskeg, is simply two smaller vehicles hooked together with a steering joint. (Fig. 11) This unit was assembled to permit field assessment of the steering principle in muskeg. The vehicle was not intended as a prototype.

Application of the machine as an 8-ton transporter demonstrated the superior mobility available from the extremely long configuration. The suitability of the joint-force steering to oilfield use was confirmed. Also confirmed was that this method of steering causes only minor muskeg mat damage in comparison with the conventional, differential track steering.

Following the success with this vehicle, a version especially suited to geophysical work was constructed using a single engine. Power for the rear tracks is transmitted through the articulating joint. Mobility and manoeuvrability of this machine are exceptionally good.

The design principle has also been continued in the 'Musk-Ox', shown in Fig. 10. The vehicle, in service since April 1959, has carried 20 ton payloads through muskeg and soft clay. In one case the vehicle penetrated 45 in. into the muskeg while carrying a 19 ton payload. Even at this deep "sinkage" it was able to traverse a 3 mile stretch of muskeg without any indication of imminent mobility failure. Evaluation of this machine in field service is continuing. To date the machine has met all of the design requirements.

Review of the Present Position

Muskeg technology although far from complete is now fairly useable. An orderly classification has been devised and proven reliable. Some ranges of mechanical properties are known. Construction and access techniques have been developed and applied with predictable results. Vehicles capable of providing reliable, all-season transportation with payloads to 20 tons are available.

Sufficient facility with muskeg has been achieved to permit the conduct of more detailed engineering investigations of its mechanical properties. These further investigations must be carried out to improve both the reliability and the economics of engineering structures in muskeg. When muskeg can be handled as a routine engineering material it will no longer be a deterrent to the development of some of Canada's most valuable known resources.

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Fig. 11. Eight Ton Articulated Transporter (Centipede). Inset: Close-up of Steering Joint.

ENGINEERING ASTRIDE

THE BORDER

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From a talk given by the author at the Cleveland Convention of the American Society of Civil Engineers, May, 1959.

A few months ago, standing on the top of the great earth dyke which flanks the Canadian part of the immense new power house at Barnhart Island on the St. Lawrence, the writer had by his side a close friend, a distinguished scientist and engineer from a distant land. The Director of the St. Lawrence Project for the Hydro-Electric Power Commission of Ontario, standing there in the warm sunlight of that lovely summer day, told how this vast construction project had been carried out by two countries, working independently but side by side, without the slightest difficulty or real argument from the very start of the actual work. The foreign guest was amazed. "How can such things be?" he asked. "How can two great countries such as yours co-operate so closely? And if you can do it, why cannot other countries do the same? What is the secret?" These questions are worth considering, but without launching into the usual eulogy about the more than five thousand miles of undefended frontier.

IT IS doubtful if any of the popular speakers about the Seaway has reminded his audience, when talking about the frontier, that one of the great early American border forts was found to have been built in Canadian territory when surveys were checked. To be reminded of such an early piece of construction *really* astride the border may, however, provide a good starting point for a realistic look at the inter-relations of American and Canadian civil engineering, with special reference to works that are near the long border.

The St. Lawrence Seaway will assuredly stimulate greatly the commerce on the vast international waterways provided by the Great Lakes. Built with all the accustomed speed of modern construction, the Seaway and associated power works constitute a monumental project of civil engineering. When they were officially dedicated, there may have been some who remembered that it was almost exactly 27 years since (on July 18, 1932) a solemn treaty was signed covering the prosecution of this great undertaking. Unfortunately, the treaty failed to win the necessary two-thirds majority of the votes of the U.S. Senate and so it proved to be abortive. Canada had to wait. Even the imperative of war failed to win a simple majority of senatorial votes for the executive agreement prepared to authorize the start of construction in 1941.

These things are not said in any way critically. They are statements of historical fact that show that the answers to the simple questions cited at the outset are not clear-cut. The delay in the start of construction had many consequences, not the least of which was that the Province of Quebec, without the power that could be developed by a dam at the Lachine Rapids, one of the seaway works, had to go elsewhere for much needed power. Work was therefore started instead on the Bersimis project in northeastern Quebec, which will eventually develop 2 million hp.

For many reasons, therefore, Canadian patience was sorely tried, with the result that in 1951 the Prime Minister suggested to the President of the United States that if the International Joint Commission would agree to the generation of power jointly by New York and Ontario in the international section of the St. Lawrence, Canada would herself carry out all the associated seaway work. The Commission did so agree, on 29 October 1952, and Ontario and New York went ahead with the power works at Barnhart, now completed and in operation. Before Canada could get started on the Seaway construction, however, other factors had emerged which eventually led to the international agreement under which the job has been successfully carried through to completion—as a Canadian project on the Canadian part of the river from Montreal to Lake St. Francis, and as a joint project with the United States in the international section from there to Lake Ontario, all costs being shared. In this joint project the lift from the tail-water level at Barnhart is made by two locks on the U.S. side. At Iroquois, the lock to pass the Regulator Dam in in Canada. Later there may be locks at both places in both countries when the traffic so requires.

In 1952, however, it was said in some American engineering circles, statements even appearing in print, that Canada could not possibly carry out the Seaway project on her own, that her suggestion of doing so was just a political move, that she was just bluffing. That assertion, coming from fellow engineers, was not easy to take. Those who made this assertion had, apparently, never been to the eastern end of Lake Erie to see how ships both large and small manage to get to Lake Ontario, 326 feet below. This is done by way of the Welland Canal, one of the great canals of the world, which conveys the largest of upper lake freighters up and down the Niagara escarpment in just seven locks. It is entirely a Canadian achievement, just as were the five preceding, smaller

Welland Canals—in conception, design, construction and cost. Officially opened on 6 August 1932, more than a quarter of a century ago, the "new" Welland Canal cost $131,900,000. Replacement today is estimated to cost $350,000,000.

The sceptics could just as readily have gone to the western end of Lake Erie and into the St. Clair River, to have a look at the "chemical city" that has developed around Sarnia, and in particular at the installations of the largest and most successful of Canadian chemical plants. It makes synthetic rubber and was built at the height of war emergency, in 1942-43. Many will recall how critical a material rubber proved to be in the early war years and how it was decided that six synthetic rubber plants had to be built with the highest of all war priorities. Originally, it was planned that all six should be built in the U.S.A., on the grounds that even one such job was beyond the capacity of Canadian engineers and constructors.

Fortunately, the Minister in the Canadian Government responsible for war supplies knew well what the Canadian construction industry could do, for he was an engineer himself, the Rt. Hon C. D. Howe. He was able to have the original decision changed and so, after some delay, Canada was given the sixth and last plant to build. All equipment and process designs were shared between the several plants, a superb piece of American engineering, but plans for the Canadian plant site, its service structures and utilities were prepared by Canadian consultants, and the entire project built by Canadian contractors, using as many as 8,000 men on the square mile occupied by the plant. Last of the six to be started, it was said at the time that the Canadian plant was the first to be finished. Be that as it may, the fact remains that the first carload of styrene was shipped from this plant, to an unspecified destination in the United States, eleven months to the day after the first sod was turned.

Arvida

Moving a little away from the border, but still on St. Lawrence waters, many know the lovely sail up the Saguenay River, past Tadoussac, past Capes Trinity and Eternity, and finally into Ha-Ha Bay to the small port of Bagotville. Approaching the wharf there, late one fine evening in July 1942, a tourist was overheard explaining that on the other side of the tree-lined hills behind the little town there was "nothing but trees and rivers and lakes all the way to the Arctic Ocean." Little did she know that just the other side of the hills at which she was looking was the world's largest aluminum plant, at Arvida, then being expanded at breakneck speed, and that to serve it with vital power there was even then being completed possibly the greatest of all Canadian construction achievements, the building of the Shipshaw power plant. Developing 1,200,000 hp. this entire project involving five dams, large tunnels and a great power house, was "on the line" less than eighteen months from the start of active construction, eighteen months that included one of the most severe winters ever experienced in the Lake St. John country.

This recital of what Canadians can do will suggest the atmosphere of Texas—or should one now say Alaska, if the largest state is to produce the tallest tales? These are not tall tales, however, but matters which come to mind as one considers those pointed questions as to how two countries manage to work together so harmoniously in the carrying out of civil engineering works. This is surely done, despite the impediments that others may put in the way, because of mutual respect for what each can do when American and Canadian engineers work together and because of common high purpose. Canadian concrete experts may never persuade Americans that placing mass concrete in high lifts is good practice (thinking now of that same St. Lawrence power house). Canadians may never convince some Americans that winter concreting is an economical procedure, but both have learned much from the other; so may it always be.

And when Canadians and Americans do work together, with administrative and political hurdles removed, then the impossible becomes merely a challenge, the incredible merely a tale to be told. Think for example of the DEW Line, that great line of outposts for continental defence—much of it built in Canada, but with American money; designed by American engineers, but with some assistance regarding local conditions from Canadians; built in Canada by Canadian prime contractors but with invaluable assistance in the delivery of men and supplies from the American Navy and Air Force. There were some difficulties, naturally, but not at the joint working level. To stand on the Arctic Coast of Canada at a DEW Line installation and to be unable to distinguish Canadian workers from American is to see further vivid evidence of what can be done together.

Behind all such co-operation in the actual construction of civil engineering projects lies the much more difficult task of co-operation in the planning of these international ventures. For boundary water problems, this is done by the International Joint Commission, with equal membership from both countries, and under joint chairmanship. Another distinguished Canadian engineer, General A. G. L. McNaughton, has long served as the Canadian chairman of the International Joint Commission. This great venture in international engineering understanding has now a history of over half a century of splendid achievement. Great and difficult problems have been solved by this unique arrangement, with very few questions ever having had to be referred to higher authority or to the courts. Great problems are even now under consideration by the I.J.C. All civil engineers will hope that the Commission's work will continue to show what can be done by two nations, acting in concert, with a reciprocal sharing of responsibility, a reciprocal recognition of capabilities, a reciprocal interchange of skilled service.

Samuel Fortier

To speak of this co-operation as a reciprocal process may sound strange to some, especially to those who never think of Canada as very much more than the great white blank that appears north of the U.S. border on all too many American maps. It would be invidious to cite modern examples of the other side of the penny but if one turns back the pages of engineering history for a few moments, it is easy to illustrate what is meant. Samuel Fortier, for example, is a name now little known but a name still familiar to those few who know the history of irrigation in the western States as that of one of the great pioneer irrigation engineers of America. Fortier was, however, a true pioneer in the field of soil mechanics. Fifty years before the name *soil mechanics* had been coined, Fortier was experimenting with soil stabilization, soil compaction and other so-called modern techniques of soil engineering. And he was a Canadian, a native of Leeds, Quebec, trained at McGill University.

He graduated in 1885, but heard the call to the West soon after, for he was in Denver by 1890. His great work was done with the United States Department of Agriculture, where he became Associate Chief of the Division of Agricultural Engineering. He also served the Agricultural Colleges of Utah and Montana and was on the staff of the University of California for two periods. Fortier was not the only Canadian who helped with the start of irrigation in the West. The town of Ontario, in California, was so named by two young Canadians, the Chaffey brothers, who went out west from a small place near Ottawa in the 1830's. (Later, they also started irrigation in the Murray Valley of Australia where one may now see a memorial to them).

Turning to a different branch of civil engineering, the longest railway tunnel in North America, east of the Mississippi, is still the Hoosac Tunnel of the Boston and Maine Railroad. It is located in the heart of the mountains at the northwest corner of Massachusetts, near North Adams. Nearly five miles long, it is still in excellent condition and in regular service even though it was opened for use in 1877. How many know that it was finally built, after several false starts, by two Canadians? These were the Shanly brothers, Walter and Francis, two members of a quite remarkable group of young engineers who, by great good fortune, served Canada in the early days of her railway building and at the hey-day of canal construction. The Shanlys had gained such an enviable reputation as engineers and builders in Canada that the Commonwealth of Massachusetts invited them, in 1868, to submit a tender for the construction of the Hoosac Tunnel, after other contractors had failed. Their offer was accepted. They started work in 1869 and the tunnel was completed, on schedule, in 1874. The brothers introduced several new features into tunnel work, the most notable being the first use in North America of nitro-glycerine as an explosive; they paved the way for the great advance in tunnelling that followed in the next few decades.

T. C. Keefer

The only meeting that the American Society of Civil Engineers has ever held in Ottawa was in 1913. One of the highlights of the meeting was a garden party, held in the garden of one of Ottawa's lovely homes. In the centre of the garden was the host, then in his ninety-second year, still keen and active mentally but slowed down physically by the burden of his years. His name was Thomas Coltrin Keefer; he had been a friend of Walter and Francis Shanly. Far more than that, he was the acknowledged dean of Canadian engineers, the only man to serve twice as President of the Canadian Society of Civil Engineers (which became, in 1918, the Engineering Institute of Canada). His second term in the Canadian presidential chair coincided with his tenure of another office, for he was also the eighteenth President of the American Society, the only Canadian ever to hold this office. Small wonder, then, that he had a garden party at his home when the Society met in his own city; small wonder that those who were there regarded the event as so memorable an occasion. For Thomas Keefer was born in 1821, trained as an engineer on the early Erie and Welland Canals, steadily gaining such a high reputation that his practice at least touched almost every major Canadian civil engineering project of the nineteenth century.

Naturally, therefore, Keefer had much to do with the steady development of the St. Lawrence Canals, his work in this field continuing through most of his professional career and culminating in his membership of the International Deep Waterways Commission which conducted one of the first studies of the practicability of a deep ship canal between the Great Lakes and the sea. In this and many other ways, not least by his presidency of the A.S.C.E., he served the two countries well. At that garden party, the old gentleman could have shown a tangible link with the very first St. Lawrence Seaway which dates back to 1832, for Mrs. Keefer's father, Thomas McKay, was one of the builders of the Rideau Canal. So well did McKay execute his masonry work that, just before the Canal was opened, the Superintending Engineer, Lt.-Col. John By, presented to him a beautiful silver loving cup as token of his appreciation of work well done. The cup was bequeathed to Mrs. Keefer and is now in the possession of Thomas Keefer's grandson, another bearer of his distinguished name.

Reference to the Rideau Canal as the first St. Lawrence Seaway may be surprising to those who have never heard of the Rideau Waterway. It is the Canal that joins the cities of Ottawa and Kingston, formed by the canalization of two rivers and the linking of their headwater lakes. It is 127 miles long, includes 47 masonry locks and over 50 dams, large and small. And it was constructed by the Royal Engineers of Great Britain between 1826 and 1832, through what was then the virgin forest of Upper Canada. It was built as a military waterway, as a direct aftermath of the war of 1812, to provide an alternative route between Montreal and Kingston (by using the Ottawa and then the Canal), in case hostilities should break out again and the supply line up the rapids of the St. Lawrence be ambushed from the American side.

Fortunately, the Rideau Canal had never to be used for this warlike purpose. Today, it is used as never before for invasion purposes — the invasion of the lovely Rideau Lakes by hundreds of American holiday makers. But for over 20 years it served as the first St. Lawrence Seaway, a large fleet of small steamboats plying a busy trade on the "Triangular Route" from Montreal up the Ottawa River, then up to the Rideau Lakes and down again to Kingston, usually returning to Montreal down the rapids of the St. Lawrence. In 1855, the first St. Lawrence Canals were finished after the expenditure of over $20 million, a really vast sum for the those days which almost bankrupted Upper Canada, and which had appreciable influence upon Canadian history. The great activity on the Rideau was over. For the next 103 years, shipping was to sail up and down between the sea and the Great Lakes, using the St. Lawrence Canals which Canada built and rebuilt on her own. The Seaway of 1959 is no new thing, it should be recalled, but just a greatly enlarged version of what Canada herself has provided for international use for over a century, and without charge for these many years.

Thomas Keefer might well have told about all this, with a smile, had one been privileged to chat with him in his garden on that June day in 1913. He would certainly have told of one of his earliest boyhood memories—how, on a day in November 1829, he had seen the first two vessels to use the first Welland Canal, as they passed his home at Thorold, sailing side by side, one American and one Canadian, on their way up from Lake Ontario to the Welland River and so into Lake Erie. One hundred and thirty years later, two fleets of boats, gunboats but sailing on peaceful occasions, side by side in true naval comradeship, come up again from the sea, this time officially to participate in the opening of the greatest seaway link of all. As a part of the ceremonies on that day a stone was unveiled, granite set into the solid concrete of the great power house. One need go no further than this stone to find the answer to those early questions, for there engraved for all to see, for all time, are these words:

> *"This stone bears witness to the common purpose of two nations whose frontiers are the frontiers of friendship, whose ways are the ways of freedom, and whose works are the works of peace."*

COFFERDAM AT MILE 6 QUEBEC CARTIER MINING RAILROAD, PORT CARTIER, QUEBEC

J. Zorzi, M.E.I.C.,
Consulting Engineer, Montreal

One of the interesting problems encountered during the construction of the railroad from Port Cartier to Lac Jeaninne was the centre pier for the bridge over the Rochers River at Mile 6. The problem was not uncommon—about 13 ft. of water at low water, a river bed consisting of soft silty clay about 45 ft. deep, then a layer of sand overlying bedrock.

THE UNDERSIDE of the foundation is about 22 ft. below the low water surface and 9 ft. below the river bed. The reinforced concrete foundation for the pier is 24 ft. x 50 ft. x 6 ft. deep. It is supported on ninety 12 in. x 12 in. end bearing piles. All outside piles are driven on a batter of 1:4. Any standard steel sheet piling cofferdam would have had to be clear of the batter piles and driven into the sand below. Even if sheet piling long enough and strong enough had been available which it was not, and if there had been enough passive resistance in the few feet of sand overlying the bedrock to build a standard cofferdam, the cost would have been out of line. A two-wall jetty type, a cellular type and a crib cofferdam were also investigated and discarded for various reasons. It was finally decided to build the cofferdam as shown on Fig. 1. and 2.

New Type Driving Template

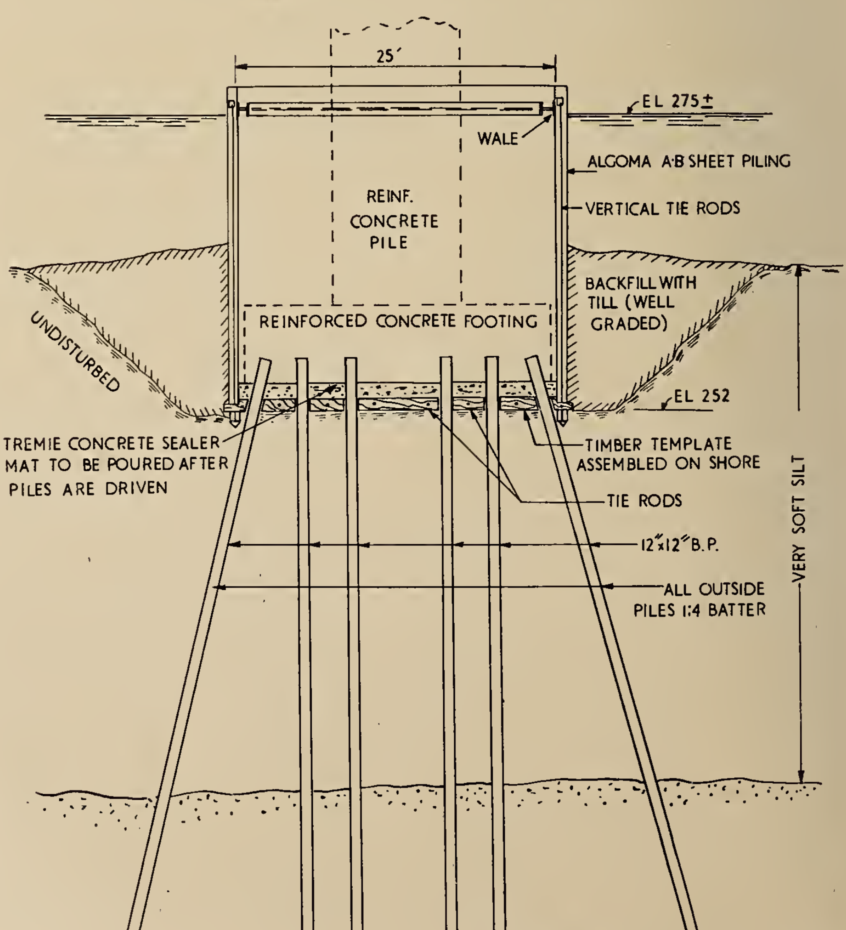
The idea was to excavate to somewhat below the underside of the footing, then to build a rigid and solid driving template slightly larger than the pier footing and strong enough to resist lateral pressure and distortion. The template was to have exactly-located guide holes for all the permanent bearing piles and a ledge around the perimeter on which a sheet piling wall could be set. This template or working platform was to be sunk onto the excavated river bottom with the centre lines in the exact position of the pier. Next the bearing piles were to be driven through the guide holes and a sheet piling wall was to be set on the ledge around the perimeter. The template was to act as bottom wale and brace and also support the sheet piling vertically. The setting up of the sheet piling wall could be done before or after the bearing piles were driven.

Good in Unstable Soils

If the soil was suitable, backfilling around the outside would hold back the water and the pumping out of the cofferdam could be done. If the soil was porous or susceptible to piping, a concrete seal could be poured under water on top of the template. After the concrete had hardened and bonded to the bearing piles the dewatering could be accomplished. In this case the concrete sealer mat would serve a two-fold purpose, first to seal the bottom against entry of water and reduce the buoyancy of the cofferdam by the weight of the concrete, and secondly to utilize the withdrawing resistance of the bearing piles against the uplift by bonding of the concrete to the piles. In either case the time required to construct the pier would be greatly reduced and the cofferdam would have to be only slightly larger than the pile cap in spite of the batter piles.

The owner engineers who had to approve of the method to be used in building the pier did see the advantage of the method outlined above and approved without hesitation.

Fig. 1. Cofferdam — Section A-A



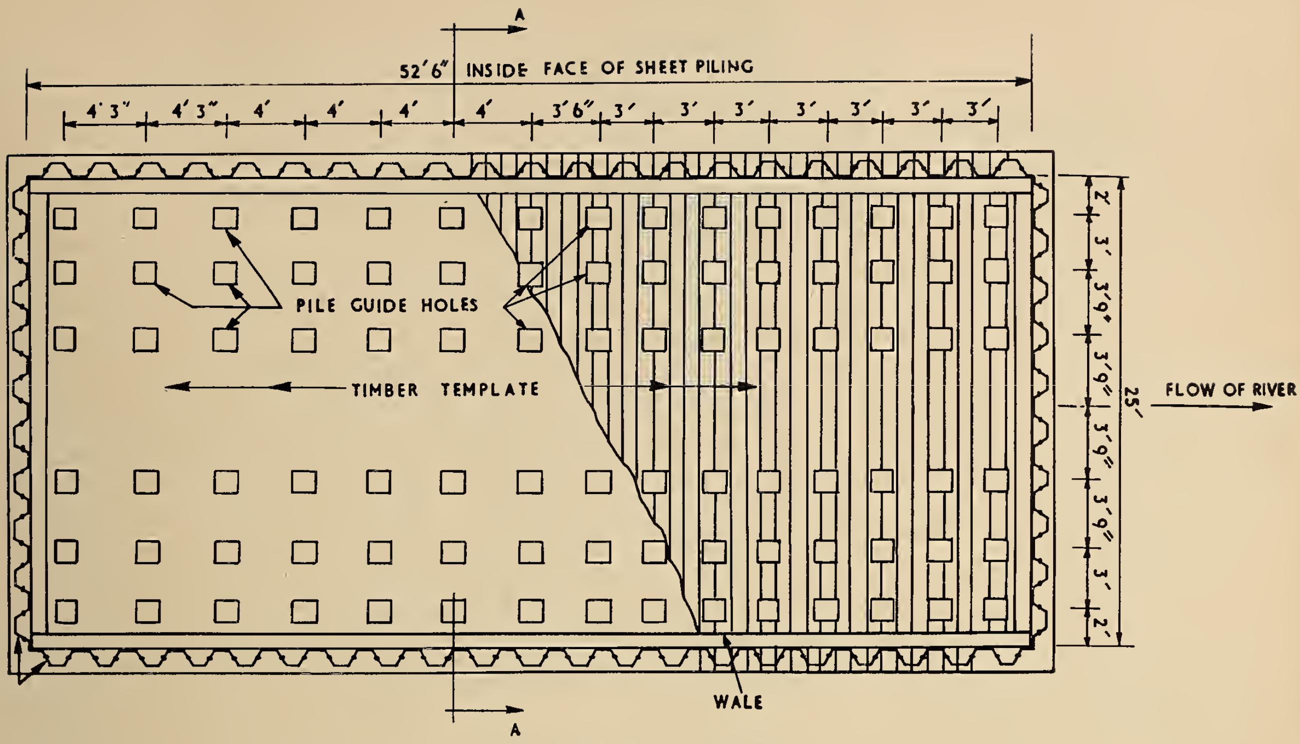


Fig. 2. Plan of Cofferdam

Construction Procedure

A standard timberpile approach to the pier side was constructed. The river bed was excavated with a clamshell as shown on the drawings. At the same time the laminated timber template was built on shore. The timbers were pre-drilled to a template and then slipped over the longitudinal tie rods. The overlapping rods were tightened as the work progressed. After all the timbers were attached to each other, the pile guide holes were located in their respective positions and then cut out with a power saw. The retaining wall shelf all around the outside of the template was then cut out. The longitudinal stringers were now bolted to the underside. The vertical tie rods were attached in their respective positions. The template was pulled across the ice to the open water over the excavation. After placing the platform in its exact position at water level, four guide piles were dropped plumb through the guide holes and partly driven. A predetermined number of steel piles (just a few tons in weight above the buoyancy of the timber) were loaded on the template. The crane let the platform sink slowly to the excavated river bottom, the guide piles assuring its exact location. A frame of 12 in. x 12 in. timber of the same overall dimensions as the shelf on the submerged template was positioned and allowed to freeze into the ice. Starting on an upstream corner, the sheet piling was now threaded onto the ledge of the template and tied to the 12 in. x 12 in. timber frame at water level. Backfilling with till to the level of existing river bottom was done. The backfill served two purposes. First, it was to hold the sheet piling on the shelf and secondly, it was to keep the water from piping through during the unwatering period at a later date. The bending stress in the secondhand steel sheet piling after backfilling and unwatering, was calculated to be about 13,800 p.s.i. This was considered well within the safe limits for this type of work and steel used.

Water Seal

The driving of the piles through the guide holes was now started. Some of the piles had to be cut under water by a diver at the required elevation. After all piles were driven, a tremie concrete sealer mat was poured on top of the template. When the concrete had hardened enough and bonded to the piles, the unwatering was carried out and the rest of the piles cut. The foundation was built in the dry and in the usual manner.

Possible Improvements

As in everything else that is new and untried, there were details that could have been and will be improved. The guide holes should have been a ½ in. larger each way. There should be about 2 ft. of clearance all around the foundation to accommodate the pumps. All vertical ties and cross bracing should be made of wire rope. The excavation should be levelled with gravel before the template is sunk into position. The shelf on the template should be higher and wider for easy threading of the sheet piling. There should be extra stringers under the template.

Human Factor

Before starting on this project the superintendents, foremen, and skilled labourers had to be won over to the new scheme. The work had to be explained in detail with answers to all questions. Most were eager, all were willing, but a few were skeptical to the day of unwatering. The idea found a different reception with the engineers who had any contact with the job. They were very keen, interested, encouraging and helpful in every way.

Discussion

A METHOD OF DETERMINING THE POWER POTENTIAL OF RIVERS WITH MANY RESERVOIRS AND POWER PLANTS

G. S. Cavadias, M.E.I.C.
Consulting Engineer, Montreal.
The Engineering Journal, October 1959, p. 103.

Discussion by R. Clinch

Mr. Cavadias is to be congratulated on having presented a paper dealing with one aspect of system planning, a subject which is assuming ever increasing importance at the present time. The primary object in system planning is to meet the demand for power and energy at the lowest possible cost. The methods employed in achieving this object will depend among other things on the nature of the demand, the cost of installation at the available power sites, and the cost of transmission from the individual sites to the load centre.

In determining the installed capacities at individual plants on a river, Mr. Cavadias has used a condition that the sum of the energies produced by the individual plants should be a maximum. This, in effect, resolves into a condition that secondary energy production should be a maximum. I suggest that in the majority of power systems, the cost of installation at available power sites and the cost of transmission are more important factors which should be taken into account.

The inclusion of these factors will, of course, complicate the problem considerably, and with all but the most simple of systems, a trial and error approach is desirable in determining the most economic installations at the various plants of the system. In this method, the cost of power and energy are compared for a number of possible installations at the various sites, taking into account installation costs, transmission costs and losses, drawdown at the storage reservoirs and power sites, voltage regulation and any other characteristics of the electrical transmission system which may impose limitations on system operation.

It is indeed fortunate that reliable high speed computers are now available for the solution of problems of this type, especially since the majority of power systems in Canada now include both hydro-electric and thermal-electric generation.

Discussion by K. Renger, M.E.I.C.

This paper is probably intended only for preliminary assessment of the power potentialities. I presume that the additional condition that the power production by each individual plant be as uniform as possible is meant to be of a secondary (maximum uniform total power production first) nature since it would increase the spillage in actual operation (especially without advance knowledge of the future run-offs) and reduce overall efficiency of the whole system if carried too far.

The assumption Item 2, "Power production as uniform as possible" (of all plants of the hydro system) is also not realistic if the hydro system is supplemented by thermal-electric plants as is already generally the case and will be increasingly so.

The method shown for determining the installation capacity at the individual plants is based on maximizing the energy output for a given total installation and assuming that the storage capacity is known. Actually both the total installation and the storage capacity are not known. On Page 10 the load factor was assumed (65%). To assume the load factor intelligently requires, among other information, estimate of the incremental hydro plant installation costs (including transmission) and of the installation and energy costs for alternative generation. The load factor to be assumed may range from say 30 to 90% depending on many factors (if it is certain that integration with a big power system is impossible then the range would be much narrower). Accepting that the load factor assumed has the proper value, it is still not certain that the suggested method represents the most economical planning because there are bound to be differences in incremental plant costs per Kw installed and also differences in incremental transmission costs.

Let us look at the example presented in the paper:

Plant P_1 has a head of 805 ft.
Plant P_2 has a head of 535 ft.

Knowing nothing else one would expect that the incremental installation costs for plant P_1 are less than for plant P_2. Assuming that everything else is equivalent at both plants, one could expect a higher load factor installation at plant P_2 than at plant P_1 for economic reasons. A look at Fig. 6 shows than plant P_1 would be a very high load factor installation whereas plant P_2 would have a much lower load factor. The incremental load factor for both plants is the same according to Fig. 6 (about 16%), but the plant with the lower incremental installation cost charge per annum could be developed to a lower incremental load factor than the plant with higher incremental charge, assuming equal return per kwh from increment energy. (See proceedings 81 (No. 697) of the A.S.C.E. "Selection of Installed Capacity at Hydro-Electric Power Plants" by L. S. Wing and R. H. Griffin, May 1955). Apparently the criterion for distribution of the capacity to the individual plants implies equal incremental installation costs (more exactly: incremental charges per annum) per Kw for both plants (including transmission). Depending on the situation the departures from this assumption may be large. The final criterion for the installed capacity should be greatest overall system economy (including the thermal-electric plants, if any) and not the greatest energy output for an assumed total hydro installation. Furthermore, the storage capacities of the two reservoirs were given at the outset. Frequently they will be unknown (Cedar Lake, Lake Winnipeg, for instance) and will have to be established through economic studies trying different regulation ranges in conjunction with different stages of development, not only downstream of the reservoir but of the whole system. However, as long as no installation and storage cost estimates are available yet, the method presented in the paper is very apt to give a preliminary answer.

Discussion by J. A. Thomas, M.E.I.C.

The author has presented a very interesting and timely paper. Power studies are often made using such approximate methods and in such general terms that the results are indicative only and do not permit power contracts for the best utilization of the potential. In many cases, the basic concepts have been found to be incorrect. It is only when one is faced with the problem of predicting the water use that the complexity of the problem and the number of variables involved is appreciated. Even so, the most detailed study is very likely an approximation to what will actually evolve through subsequent experience.

The author gives, in his paper, a generalized analytical treatment which permits an organized approach to the problem. It is precise within the limits of its assumptions.

If the rivers and their reservoirs under study are to be developed to supply power to an isolated system, this method should yield a result which closely predicts the actual regulation. However, if power is to feed into a network or into a system where the supply is partly thermal, the problem is somewhat more complicated. Under these conditions, the author's analytical method is very effective in determining the energy potential.

In order to evaluate the available capacity, however, it is usually necessary to re-regulate the reservoirs in such a way that the power output is far from constant.

In paragraph 4.1, the author assumes a load factor to determine the total installation. In the system mentioned above, the load factor must be determined from the analysis of capacity benefit.

In order to do this, power duration curves of the critical months during the regulating period may be drawn and on them, the existing and proposed installations fitted. Thermal capacity usually is placed in the lower part of the curve, i.e., it is base-loaded and hydro plants are fitted above with consideration of their respective storage and pondage. Finally, when the proposed developments have been located in proper relationship to existing plants on the duration curve, the load factors, or, precisely, the capacity factor and corresponding installation may be obtained.

The writer would like to question the author on a few details of the development of his method.

Firstly, in equation (10), the term $\triangle S_a$ represents a volume, which should be divided by a time factor to produce a flow in relation to power.

The definition for load factor is given by:

$$\text{L.F.} = \frac{\text{average load}}{\text{peak load}} \text{ for a specified period.}$$

The average load will include some secondary power.

When the peak load equals the installed capacity, as is usual, the load and capacity factors are equal and this equation can be written:

$$\text{L.F.} = \frac{\text{area under duration curve corresponding to the installation}}{\text{installed capacity x period of time}}$$

This equation is quite different in concept to that used by the author.

Finally, in equation (15), the author states that the differentials $dI_2 + \ldots + dI_n$ "are now independent". This is not apparent to the writer. However, the conclusions are correct and can be seen from the following alternate analysis:

Since $I_1 + \ldots + I_i + \ldots + I_n = I$ where I is the total installation and is therefore a constant, $dI_1 + \ldots + dI_i + \ldots + dI_n = 0$.

Since I_i must be positive and finite, dI_i must be equal to zero.

The net result of the mathematical analysis is to conclude that the total duration curve is the sum of its component duration curves, a fact that is rather obvious in the first instance.

Referring to Table 1, the columns headed "Power" should more correctly read "Energy" since the values are given in Mw. months.

The writer would like to commend the author on the clear presentation of his subject and his ability to express his concepts in mathematical form.

Discussion by E. Kuiper, M.E.I.C.

Mr. Cavadias applies in essence the following procedure: He determines the maximum dependable flow, and

(Continued on page 143)

Abstracts

These abstracts of Annual General Meeting papers were not available for publication in April. Most of the 1960 AGM paper abstracts appeared in the March and April issues.

The Contribution of the Mines Branch Services to the Development of Western Canadian Mineral Resources
John Convey

The known mineral resources of the area from the Canada-U.S. border to the Arctic and from Winnipeg to the Pacific, or about two-thirds of the Canadian continent, have at one time or another come under the scrutiny of the engineers and scientists at the Mines Branch, a unit of the Department of Mines and Technical Surveys at Ottawa. Deposits of metal ores, industrial minerals and fossil fuels have been examined and, where possible, have been processed into economic feed materials for Canadian industry. The more important processes of topical significance developed at the Mines Branch include those for uranium, coking coal, asbestos, light weight aggregate and the Athabasca Tar Sands.

Manned Space Flight
Orest Cochkinoff

The re-entry phase of manned space flight presents many new problems such as stability and control of the vehicle, heat shielding, communication and deceleration effects. Vehicles may be winged and allowed to glide in or may be of a high-drag type, following a ballistic trajectory. The aerodynamic heat that is generated may be dissipated by radiation, ablation or by some other form of shielding. Two research projects are underway to take man into space—the X-15 airplane and the Project Mercury ballistic vehicle, both sponsored by the U.S. National Aeronautics and Space Administration. The X-15, probably the most advanced aircraft yet built, is constructed largely from welded Inconel X and titanium and uses a 50,000 lb. thrust rocket engine, while the Project Mercury vehicle will be of the high drag type, placed in orbit by an Atlas booster and helped to land by parachute.

Automation and Control Engineering in Canada

Corrosion Problems in Chemical Plant Instrumentation

When designing instrumentation systems for chemical plants, the same types of problems occur time after time, even though the particular plants may differ considerably from one another. These problems arise because of the nature of many of the processes that are used in the industry. The materials handled are frequently either very corrosive, or very dirty, or present an explosion hazard, or, quite likely, all three at the same time. In many cases plant designers have difficulty in finding suitable vessels, pumps, piping, valves and so on, able to withstand these difficult operating conditions, in spite of the fact that they are dealing with heavy, rugged, equipment. The difficulty of making a measurement, possibly a very delicate measurement, under such conditions, and of being able to make it reliably twenty-four hours a day, is apparent. This article will consider ways in which the instrument engineer can overcome some of the difficulties which arise when measuring process variables such as pressure, liquid level, and chemical composition. The influence of corrosive plant conditions on the designer's choice of electrical control equipment will also be considered briefly.

Pressure Measurement

It may cost $20 to measure the pressure of a clean, non-corrosive gas or liquid stream, using a bourdon tube pressure gauge. The same measurement on a corrosive stream may cost over $200. This considerable difference points out that, in addition to the problem of finding something that will work, there are economic problems as well.

Bourdon tubes are available in phosphor bronze, beryllium copper, monel, and various alloy and stainless steels, but none of these materials may be suitable for use in contact with the corrosive agent involved. In

Fig. 1. Bourdon tube gauge fitted with a diaphragm protector.

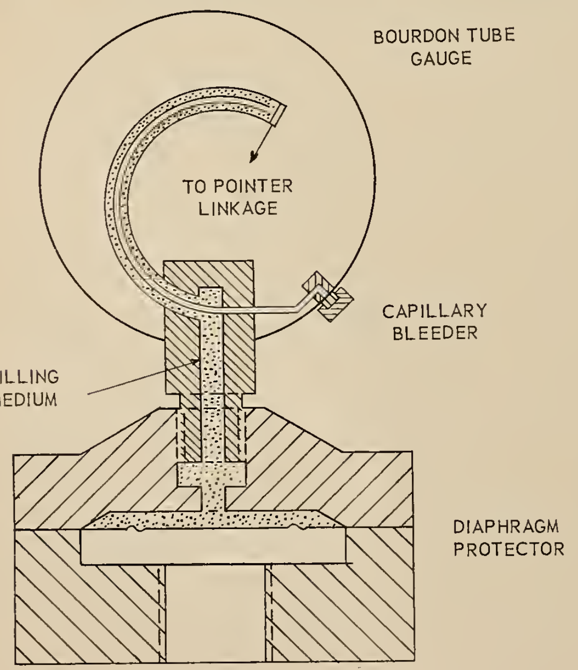
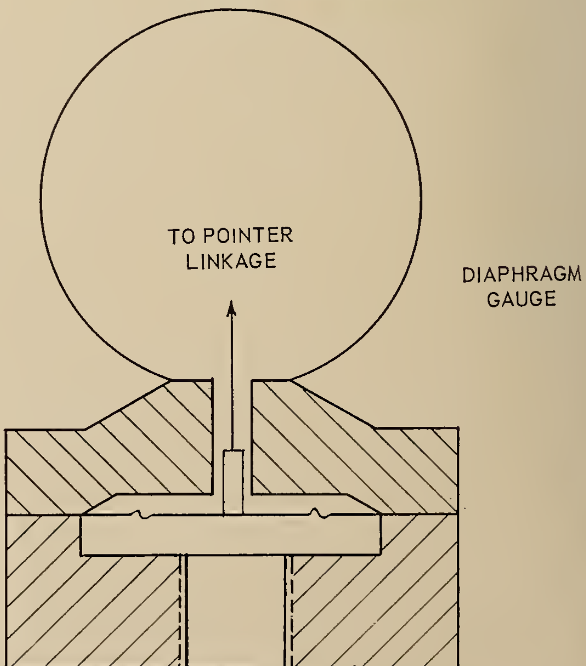


Fig. 2. Diaphragm gauge



this case, the plant fluid must be kept out of the gauge by some kind of sealing arrangement. Two common methods are by the use of a bourdon tube gauge fitted with a diaphragm protector or "chemical gauge attachment", or by the use of a diaphragm gauge in which the diaphragm itself is the measuring element. The diaphragm gauge is likely to be the less expensive alternative when it can be used, that is, for vacuum and for pressure applications up to about 300 p.s.i. This type is widely used in Europe, but is less common in North America, where the diaphragm protector is normally used. A simplified sketch of a bourdon tube gauge fitted with a diaphragm protector is shown in Fig. 1. The diaphragm is enclosed in a housing, with the pressure to be measured admitted through a flanged or screwed connection to the underside of the diaphragm. The bourdon tube gauge is screwed into the top of the space above the diaphragm, including the bourdon tube, being filled with some inert oil or grease. A capillary bleeder is usually fitted as shown to ensure that all the air is removed from the bourdon tube during the filling operation, so that process pressures will be transmitted accurately through the diaphragm and filling medium. The diaphragm gauge is shown in Fig. 2. The process pressure or vacuum is applied to the underside of a stiff diaphragm, the other side of which is at atmospheric pressure. The small movements of the diaphragm which result from changes in the process pressure are geared up through a sector and pinion to drive the gauge pointer.

Neither of these gauges is as accurate as a straightforward bourdon tube gauge of the same quality. The diaphragm protector introduces errors because the diaphragm is not perfectly flexible and because of the effects of temperature changes on the filling medium. The diaphragm gauge is less accurate because the diaphragm is not such a good pressure measuring device as a bourdon tube. However, for corrosive applications, they both have the advantage that they can make use of a wider range of materials of construction for the "wetted parts" than can bourdon tube gauges. The diaphragms can be made of tantalum, or of corrosion-resistant alloys, or can be plastic-coated. The lower housings can be made of similar materials, or of plastic- or rubber-lined steel, or of polyvinyl chloride. Some of these materials are very expensive, and on applications where they have to be used it becomes very costly to measure a process pressure. There are many corrosive applications, however, working at up to 250 p.s.i. at 150°F, where a diaphragm housing made of inexpensive material such as p.v.c. is perfectly acceptable.

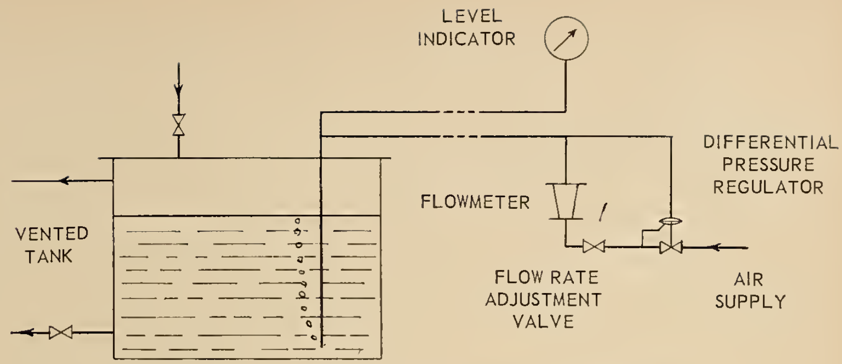


Fig. 3. "Bubbler" method of determining liquid level.

Liquid Level Measurement

Liquid level measurement on corrosive applications provides examples of two alternative approaches to the problem of keeping the corrosive agent out of the instrument, by the use of air purges and the use of sealing fluids. The obvious example of a purging system is the "bubbler" method of determining liquid level, shown in Fig. 3. Here a dip pipe, which may be made of glass, p.v.c., or other inexpensive corrosion resistant material, projects down into the liquid in the tank. A constant small flow of air is supplied to the dip pipe through a flow regulator and a flowmeter. The flow regulator maintains the pressure drop across a manually set valve constant, so that the purge flow will be constant whatever the liquid level and the resulting back pressure in the dip pipe. This back pressure can be indicated on a local or remote pressure gauge calibrated in feet of liquid or gallons, as required, or can be fed into a computing relay which will generate a standard 3 to 15 p.s.i. pneumatic signal proportional to the liquid head for transmission to a receiver type indicator or recorder controller.

When the tank is under pressure or vacuum, a differential pressure gauge or transmitter must be used, with a second air purge connected into the line from the tank vapour space to the low pressure side of the gauge. Difficulties can arise with this system when the tank pressure fluctuates rapidly over a wide range, because of the possibility that tank liquid will be blown into the connecting tubing and the gauge. There are other instances when a bubbler system cannot be used. One of these is when the tank liquid is a saturated solution. The dry air bubbling into the solution takes up moisture, resulting in the deposition of crystals at the bottom of the dip pipe, which rapidly causes a blockage. Another case is where the tank liquid is saturated with a gaseous product, the tank being vented to the header collecting this product. In these circumstances leakage of air into the system may have to be minimized, and even the low purging flow from a bubbler cannot be tolerated.

An example of the use of sealing fluids is the measurement of the level of a flashing corrosive liquid in a pressurized or evacuated vessel using a differential pressure transmitter. The problem here is not only corrosion but also condensation in connecting lines to the instrument. If an inert sealing liquid is used in these lines, the differential pressure measuring device must have negligible displacement as the applied differential varies, otherwise pumping will take place, making it impossible to keep the line full of sealing fluid, and resulting in errors in measurement. The pneumatic differential pressure transmitter, shown in a simplified form in Fig. 4, satisfies this requirement. The pressure differential is applied across a diaphragm, tending to move the diaphragm up, and the right hand side of the force beam down. The baffle approaches the fixed nozzle, so increasing the nozzle back pressure, which is applied to a pilot relay, increasing the relay output pressure. This increased pressure is applied to a follow-up bellows which tends to move the right hand side of the force beam upwards, resulting in a force balance method of operation. The relay output pressure is a measure of the differential pressure across the diaphragm, and the transmitter is so constructed that an output signal of 3 to 15 p.s.i. from the pilot relay results from a differential pressure input of zero to 100% of the nominal range. Over this range, the baffle-nozzle separation will change by only a very small amount, of the order of 0.001 in. Consequently, the diaphragm displacement will be negligible as the applied differential pressure varies, and the sealing fluid in the lines to the high and low pressure sides of the transmitter will not be pumped out.

In this type of level measurement, the choice of sealing fluid and of the method of installation must be made with some care. The seal and tank fluids must obviously be immiscible, and the difference in their specific gravities should be as large as possible. Heavy, inert liquids such as fluorinated hydrocarbons are useful sealing fluids, although they are rather costly. When the sealing fluid is heavier than the tank liquid, the transmitter would obviously be installed below the level of the connections to the tank.

Chemical Composition Measurement

Continuous process stream analyzers, such as infra-red absorption, ultra-violet absorption, and thermal conductivity analyzers, are widely used in the chemical industry for the continuous measurement of process stream composition. Many of these analyzers have been developed for plant operation from laboratory type instruments. Most of the operating troubles which are experienced with plant analyzer installations arise because of the dirty, contaminated nature of the streams being monitored. Gas streams, for instance, may be contaminated with solid and liquid corrosion products which must be kept out of the analyzer if reliable operation is to be achieved. A sampling system must be designed that will deliver a clean, representative sample, at a suitable pressure and temperature, to the analyzer cell.

As an example, consider the thermal conductivity analyzer shown in Fig. 5. This type of analyzer is used to measure the composition of binary gas mixtures when the thermal conductivity of one component is significantly different from that of the other component. The analyzer consists of a Wheatstone bridge, one arm of which is sealed in a reference cell, whilst another arm is enclosed in a sample cell containing a sample of the gas to be analyzed. The resistors in the sample and reference cells are heated by the current passing through them, and cooled by thermal conduction through the gas surrounding them. Their temperature, and therefore their electrical resistance, is then dependent on the thermal conductivity of the gas. Bridge unbalance can therefore be related to the composition of the gas being analyzed. The sample cell is so arranged that its resistor is not directly in the sample stream, otherwise the rate of cooling would be dependent on the sample flow rate. Gas from the sample stream can only diffuse slowly in and out of the sample cell, so that the cooling of the resistor is dependent only on conduction through the gas.

If the analyzer were measuring low concentrations of hydrogen in air, the reference cell would be filled with air. Hydrogen has a much higher thermal conductivity than air, and as the hydrogen concentration increased, the temperature of the sample resistor would decrease, resulting in a decreased electrical resistance and a change in bridge unbalance.

Thermal conductivity analyzers are available with glass-coated resistors enclosed in glass cells, with glass sample connections, so that corrosion does not normally present any problem. However, if the sample stream contains solid or liquid contaminants that can be deposited on the sample resistor, the analyzer output will rapidly become meaningless. Even a slight film on the resistor will have a considerable effect on the heat transfer to the gas. The problem then is to filter and scrub the gas sample very thoroughly so that only infrequent cleaning will be required. If the analyzer does go out of calibration, which in the hydrogen-air case would be shown by an inability to set the zero with 100% air in the sample cell, the cell must be washed out with a suitable solvent and then thoroughly dried before being returned to service.

A typical sampling system for such an analyzer is shown in Fig. 6. When long sample lines are involved, one problem is to cut down the time it takes the sample from the process line to reach the analyzer, so as to get a rapid analyzer response to changes in the process stream. Small bore sample lines are used, to give high velocities. However, the maximum flow through the analyzer, above which flow responsive effects appear, might be of the order of 2 c.f.h., which may be insufficient to give the required velocity. In such cases, a by-pass is installed around the analyzer, and sufficient flow is by-passed to give the required response time. On the low flow line to the analyzer, components such as the filter and the gas wash-

Fig. 4. Pneumatic differential pressure transmitter.

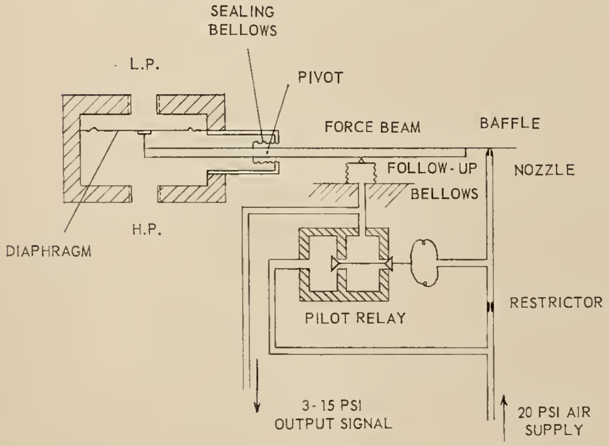
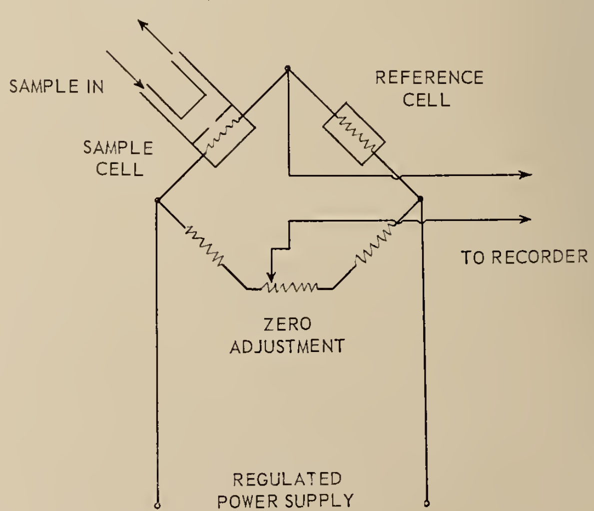


Fig. 5. Thermal conductivity analyzer.



ing bottle should have the absolute minimum gas space volume. Ceramic and porous stainless steel filters are available which have been specially designed for this service. When the sample has to be dried before it can be passed through the analyzer, a drying agent such as concentrated sulphuric acid would be used in the wash bottle. If the moisture throughput in the sample is high, necessitating frequent replacement of the sulphuric acid, a different drying system with a larger acid capacity can be used. In this system, acid from a large reservoir is pumped continuously to the top of a packed glass column, down which it flows back into the reservoir. The sample flows up the column and into the analyzer. The acid can be circulated by an air lift type of pump.

Many process stream analyzers are enclosed in thermostatted cases, and it is sometimes necessary to heat or cool the sample flow in order to obtain satisfactory operation. This factor also has a bearing on the choice of a suitable location for the analyzer. With some types of analyzer it may be necessary to wait for a period of hours, after removing and replacing the cover, for conditions to become stable again. Now in warmer climates it may be possible to mount the instrument, on an outdoor plant, on a platform half way up a distillation column, but this is not possible in the Canadian climate. Aside from the discomfort of carrying out maintenance work on such an installation in winter, temperature effects would be very serious and lengthy whenever the case was opened. On the outdoor type of plant, analyzer huts are essential. A small, heated building can usually be located so that several analyzers can be installed in it without requiring excessively long sample lines. The analyzers would then transmit electrical signals to indicators or recorders located in the plant control room. The cost of an analyzer may be \$3000 to \$10,000 or more, so that the cost of the building required is small by comparison, considering that it will probably make the difference between a workable and an unworkable installation.

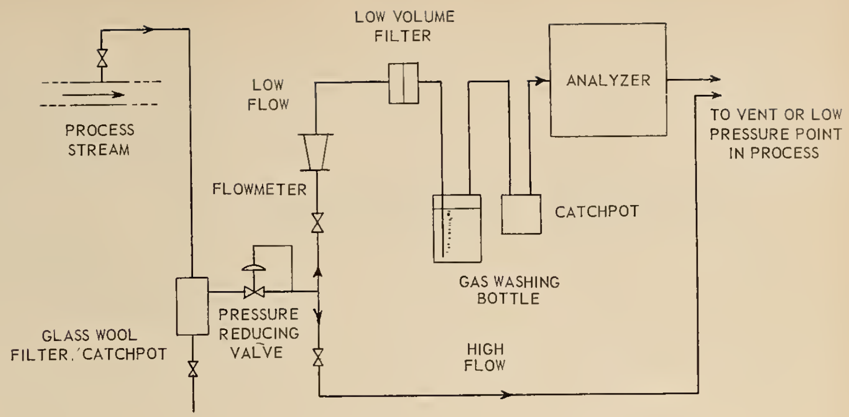


Fig. 6. Typical sampling system for a thermal conductivity analyzer.

Electrical Control Equipment

On plants where the atmosphere is corrosive or hazardous, pneumatic transmission and control systems have some advantage over their electronic counterparts. Air from pneumatic relay vent ports purges the cases and keeps out plant fumes, and they do not present any explosion hazard, whereas electronic equipment requires explosion-proof enclosures. There is one duty however for which electrical equipment is nearly always used. That is, for alarm annunciation, interlocking of equipment functions, and automatic shutdown of the plant when unsafe operating conditions arise. The necessary relaying is much easier to perform electrically than pneumatically. A typical small plant might have forty alarm conditions, such as high temperature, low pH, and so on, monitored on an alarm system, and in addition there may be twenty or so switches, actuated by process variables such as high pressure and low flow, that shut down the plant automatically when unsafe operating conditions arise. For the utmost reliability these switches will be actuated by a separate measuring system rather than by a pneumatic signal which may already have been generated for control or measurement purposes. Failure of pneumatic transmitters will then not interfere with the correct operation of the safety shut down system. Reliability considerations may also require that the shutdown system be operated on a d-c supply from a floating battery system.

Safety shutdown systems usually incorporate logical circuitry to ensure not only safe working but also safe start-up and safe shutdown. Pumps and compressors and so on must be started and shut down in the right sequence to give safe conditions at all times. Circuitry may also be required for a shutdown annunciator so that, when a shutdown switch operates, it lights an annunciator lamp and also locks out the lamp circuits associated with other switches. If this feature is not included it will probably be impossible for the operator to determine what caused the shutdown, because perhaps half the annunciator lamps will be lit seconds after the shutdown occurs.

Conventional relaying systems are usually employed for these systems, with the relays located in a non-hazardous location if possible. Even in this location, however, corrosive fumes are likely to give rise to relay contact troubles. If this is the case, hermetically sealed relays can be used. These relays are available in a plug-in form and also with solder-tag connections. Here the designer has to choose between the rapid replacement which can be made when plug-in relays are used, and the freedom from pin contact corrosion problems of the soldered connection type. Pressure switches and so on can make use of mercury tube switches, where the switch contacts are sealed inside a glass envelope.

In the future, it is likely that solid state switching systems will be used for this duty. Encapsulated logic elements will be unaffected by the plant atmosphere, and will be more reliable than electro-mechanical relays. If the system can at the same time be made intrinsically safe it will be a very worthwhile step. An intrinsically safe system would be so designed that, under normal working conditions, or under any possible fault conditions, it would be impossible to generate a spark, at the plant shutdown switch, with sufficient energy to cause an explosion. Non-explosion-proof components could then be used in the hazardous area. Such a system would be very valuable on modern plants which rely for safe operation on complex interlocking and safety shutdown systems.

Canadian Developments

New Plant for Testing Quebec Asbestos and Metals

The new pilot plant of the Quebec Department of Mines located in the St. Malo Industrial Centre is directed toward assessment and evaluation of the Province's metal and asbestos resources. Housed in a building constructed 40 years ago, the new plant comprises a sampling plant, a treatment plant and an asbestos plant on the ground floor and laboratories for mineral dressing, analytical control and asbestos treatment in the two longitudinal mezzanine sections.

The renovation and centralization of research and treatment facilities is in line with the remarkable upsurge in Quebec mining activity during the last decade. Since 1950 the annual value of the Province's mineral production has risen from roughly $200,000,000 to $460,000,000 and experts anticipate that this trend of acceleration will continue.

Professor J. U. MacEwen, head of the mechanical engineering department at McGill University, was chosen by Minister of Mines William M. Cottingham in 1958 to act as consulting engineer for the planning and installation of the new pilot plant. The 280 ft. long building has a central section 80 ft. wide and 32 ft. high and mezzanines to either side of this central section which are 20 ft. in width, 17 ft. in height. A CNR spur line extends 60 ft. into the building at the west end and a 25 ton crane, with an 80 ft. span, services this ore receiving section.

In the sampling plant the 6 in. feed material is crushed in a 9 in. x 16 in. jaw crusher operating at a reduction ratio of six to one. The 1 in. product then goes into a 30 in. cone crusher and is reduced to ¼ in. This crusher discharge drops onto a reversible conveyor belt and can be fed into either the sampling plant or the treatment plant.

A sampler retains 10% of the material in the sampling circuit and rejects the other 90%. The sample cut is crushed in a 12 in. crusher to −20 mesh and sent on by another conveyor belt to a second sampler which retains 20%. This time the selected material is crushed to −48 mesh. The process terminates with a third sample cut of 10%, rendering a final 4 lb. sample from each ton of mineral treated.

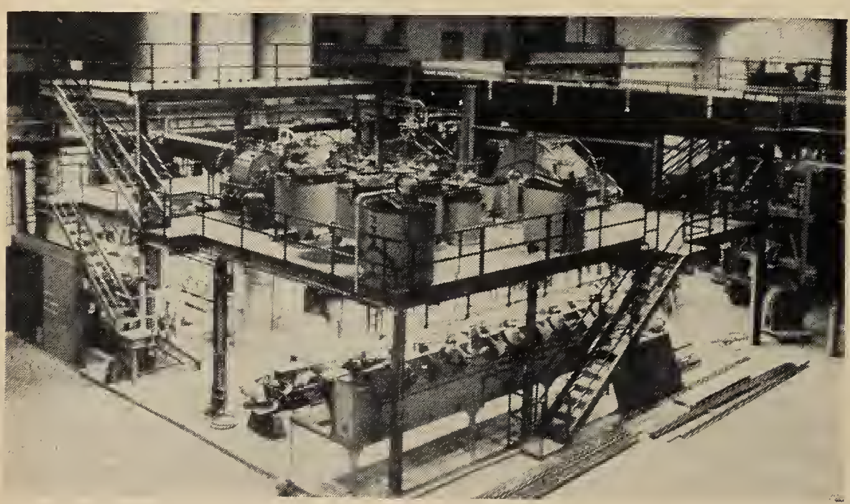
In the treatment plant the ¼ in. material discharging from the crusher goes to a screen in closed circuit with the crusher so that no oversized particles enter the grinding mills. There are two sections in this plant, one a 25 ton section, the other an 8 ton section. The flotation section is equipped with two batteries and four conditioners together with thickeners to handle both concentrates and tailings. Two drum filters, one disc filter and a portable dewatering classifier have also been installed.

In the asbestos treatment plant the 3 in. feed material is crushed first with a jaw, then two mills operating at different speeds. After each reduction, the product is screened on an oscillating screen to separate the freed fibre from the rock. The recovery of asbestos from its ores requires a very careful treatment to produce a maximum of long fibres. Collected in low pressure cyclones and a dust filter, the fibre is passed through a disintegrator for further separation and fiberization.

The laboratories are used for small-scale testing of ore concentration and for mill control through chemical analysis of samples. They include a crushing and sampling room, a flotation room and an asbestos section.

A sub-station at the entrance to the plant receives the electrical current needed for its operation. The incoming 4,000 volts is transformed to 550 volts and conveyed to five auxiliary panels in the plant and mezzanines.

The Treatment Plant: A general view of the flotation and cyanidation annex, showing the conditioners, filters and cells.



Water Power Resources 1959

The annual report issued by the Water Resources Branch of the Department of Northern Affairs and National Resources underlines the vitality of hydro-electric development in 1959 and points to an increasingly prosperous decade ahead. The water is there — in bountiful quantity in almost every province of Canada — and the demand is there — particularly from the oil, pulp and paper and mineral industries. The legislation to make possible some of Canada's larger hydro-electric developments is in progress. The recent proposals concerning the Columbia River *(Engineering Journal,* Canadian Developments, March 1960) represent a sizeable accomplishment in this field.

Although Quebec and Ontario remain well in the lead in total hydro-electric installation, British Columbia, Manitoba and the Yukon are developing their potential rapidly. Calculations are not complete, and depend largely on what the power potential of major river diversions turns out to be, but it is clear that British Columbia and Quebec individually have at least twice the raw potential of any one of the other provinces, both having a little less than 20,000,000 hp. available continuous flow at 80% efficiency.

Because precipitation is unusually light in the two territories, the favourable sites are dependent upon large storage capacities. In order to encourage development of the resources of Northern Canada, the Federal Government in 1948 set up an agency now known as the Northern Canada Power Commission for the construction and management of public utility plants. The Deputy Minister of Northern Affairs and National Resources is the chairman of this Commission and the director of the Water Resources Branch is a member.

It is interesting to note how much coal would have been necessary in 1959 to operate thermal stations in place of hydro-electric plants and turn out the same kilowattage. Water power is distinctly important in the economy of power production. Water power generated 96,516,000,000 kwh. in 1959. It takes one pound of coal (12,000 BTU per pound) to produce one kilowatt-hour of electricity, so that it would have called for 48,250,000 tons of coal, in addition to the 24,000,000 tons burned in the existing thermal stations in 1959, to produce the total electric power of that year.

Canada is exceeded only by the U.S.A. in total water power installation and by Norway in per capita output. British Columbia has an outstandingly high ratio of power output to population. Prince Edward Island's is the lowest.

Developed Water Power in Relation to Population

Province or Territory	*Installed Capacity—hp. 31 Dec. 1959*	*Estimated Population 31 Dec. 1959*	*Installation per thousand population hp.*
British Columbia	3,509,460	1,592,000	2,204
Alberta	312,595	1,264,000	247
Saskatchewan	128,835	907,000	142
Manitoba	778,900	892,000	873
Ontario	7,982,151	6,029,000	1,324
Quebec	11,315,407	5,062,000	2,235
New Brunswick	254,875	595,000	428
Nova Scotia	183,168	719,000	255
Prince Edward Island	1,660	103,000	16
Newfoundland	370,135	453,000	817
Yukon & Northwest Territories	51,240	34,000	1,507
Canada	24,888,426	17,650,000	1,410

Water Power Resources of Canada Bulletin No. 2702.

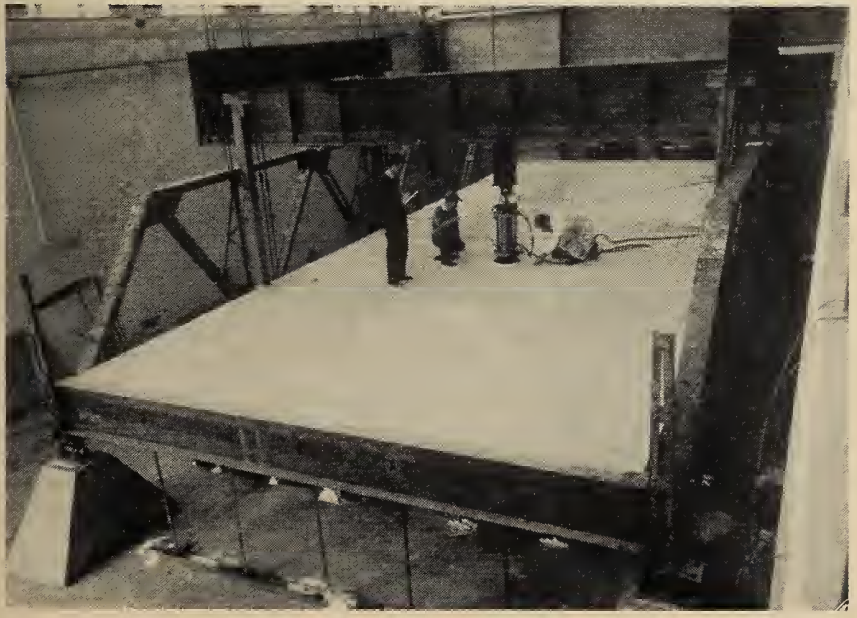
Available and Developed Water Power in Canada At End of the Year 1959

Province or Territory	*Available continuous power at 80% efficiency—hp.*		*Installed Turbine Capacity hp.*
	At Ordinary Min. Flow	*At Ordinary 6-Months Flow*	
1	2	3	4
British Columbia	18,200,000*	19,400,000*	3,509,460
Alberta	911,000	2,453,000	312,595
Saskatchewan	550,000	1,120,000	128,835
Manitoba	3,492,000	5,798,000	778,900
Ontario	5,496,000	7,701,000	7,982,151
Quebec	10,896,000**	20,445,000**	11,315,407
New Brunswick	123,000	334,000	254,875
Nova Scotia	30,500	177,000	183,168
Prince Edward Island	500	3,000	1,660
Newfoundland	1,608,000	3,264,000	370,135
Yukon Territory	4,678,000*	4,700,000*	38,190
Northwest Territories	374,000	808,000	13,050
Canada	46,359,000*	66,203,000*	24,888,426

* These figures reflect the effect of possible stream flow regulation based on known storage potentials.

** These figures undoubtedly will be revised substantially with the completion of the review of water power resources which the Quebec Department of Hydraulic Resources now has under way and in which the Water Resources Branch is co-operating.

This old bridge from Southeastern Ontario was dismantled last summer and re-erected in the structural laboratory at Queen's University, Kingston. Loads are being applied to the deck by means of a 40-ton hydraulic jack, the reaction being taken by the transverse girder above, which is anchored by the tie rods on either side of the bridge. Most of the measurements are taken on the under side of the deck.



CGRA Pavement Research

This summer the Canadian Good Roads Association will continue its pavement research and evaluation project begun a year ago, hoping that by next October they will be ready to report at the Toronto convention on phase 1. During the winter the vast amount of data collected during 1959, when several thousand miles of pavements were studied, was sorted and analyzed. Six to seven thousand more miles will be covered this summer. The papers to be presented in October will cover these subjects: the CGRA Benkelman beam procedure and its application in testing flexible pavements; rigid pavement tests; determination of spring load carrying capacity from Benkelman beam deflections; method of design for strengthening existing pavements; and the influence of shoulder types on flexible pavement strength.

Canada-USSR Trade Agreement

A three-year renewal of the Trade Agreement between Canada and the Union of Soviet Socialist Republics was

(Continued on page 93)

International News

Space Vacuum Laboratory Opened at St. Cambridge, Mass.

The National Research Corporation in Cambridge, Mass., has recently established a space vacuum laboratory to provide ultra-high vacuum testing facilities for the nation's missile and space vehicle programs. Located in the headquarters of the Corporation, the laboratory makes it possible to test equipment for space flight at a minimal cost compared to that of actual space flight testing.

The ultra-high vacuum chambers achieve pressures equivalent to altitudes in excess of 400 miles above earth. Bearing friction, lubricants and the behaviour of metals and plastics under extreme conditions are but a few of the factors which can be tested. Tests of a year's duration are now being planned for the components of an American reconnaissance satellite.

The test chambers range in size from a 14-in.-diameter by 36-in.-high bell jar type system reaching pressures as low as 2×10^{-10} mm of mercury to a large 3½-ft.-diameter stainless steel tank which has attained 4×10^{-10} mm of mercury.

Production Developments in the USSR

Extracted from The 1959 Sir Alfred Herbert Paper by Dr. D. F. Galloway, Director, Production Engineering Research Association of Great Britain.

Whereas in 1913 Russia's industrial production amounted to 2½% of world output, it now represents nearly 20% and exceeds the combined output of France, Britain, and West Germany. The same is true of her generation of electrical power. Russian industry has been gradually moving eastward in order to exploit the large mineral deposits of the Urals, Siberia and the Kuznetsk Basin. Factories in many cases have been built to accomodate the industry of an area; canning machinery, for instance, is manufactured in the Crimea where Russia's highly developed canning industry is centralized.

Although Russian factories are generally clean, natural and artificial lighting in working areas is poor and little use is made of colour for decorative purposes. There is a strong drive towards automation in Russia, but mechanical handling in factories is still sparse. Machines have been purchased from Czechoslovakia, Germany and elsewhere, but there is a movement on now to incorporate Russian machine tools into Russian industrial processes as far as possible.

Discoveries in research laboratories—both in the individual factories and in research centres—are intensively applied to production methods. The First State Ball-Bearing Plant in Moscow is a fair sample of Russia's industrial progress, where research has been incorporated into routine. The plant produces 70,000,000 bearings annually ranging in size from ½ in. to 5 ft. outside diameter and with weights of approximately 1 oz. to several tons. The plant includes a separate automatic factory built in 1952 which produces 2,000,000 bearings annually with a labour force of 12 production workers and 18 maintenance engineers. The automatic line is made up of 150 machine tools, several heat treatment furnaces, special assembly presses, inspection equipment and a unit for greasing, wrapping and packaging the bearings.

Structural Problems of Nuclear Reactors in Great Britain

A report submitted by Dr. A. H. Chilver, Cambridge University.

One of the most interesting fields of structural development in Great Britain during the past few years has been that of nuclear reactor design.

Nuclear power stations under construction are of the gas cooled, graphite moderated, natural uranium type. The structural requirements introduced new problems of irradiation of materials within the reactor. In addition, many new problems of large thin-walled pressure vessels, the creep of materials at elevated temperatures, thermal stresses, and biological shielding are encountered.

The core of a reactor is contained in a thin steel spherical shell, usually about 50 ft. in diameter and 3 in. thick. Gas pressure within the shell is approximately 200 lb./in.^{2} The carbon dioxide gas is circulated through large ducts connecting the sphere to heat exchanges. The main structural problems of the sphere are the duct connections, its support, and the welding of spherical segments during construction.

A considerable amount of research is being undertaken at universities and other research institutions, as well as in the industry itself. Design methods are being developed to deal with problems of stresses in spherical and cylindrical shells due to discontinuities, the buckling of shells and the creep of materials.

Computer methods are also being developed to deal with highly redundant elastic and also plastic structural systems.

West German Reactor Plans

An experimental reactor of the boiling water type will be the source of 15,000 kw. of electricity at Kahl, on the Main River, by the end of 1960, according to the *Bulletin* of the International Atomic Energy Agency. The plant is being built by Essen and Frankfurt-am-Main manufacturers and is based on an American design. To be operated by an Essen utility, the plant will provide technical and cost data for future nuclear power development and will help in the training of nuclear engineers.

Construction of a gas cooled, graphite moderated, high temperature reactor to produce 15,000 kw. is scheduled to begin soon near Juelich. Designed by a Mannheim firm for a Duesseldorf industrial group, the plant will be a joint industry-government undertaking. Government aid is also going into three other nuclear plants, each of approximately 100,000 kw. Five research reactors are now in operation in the German Federal Republic, and three more are under construction. It appears that design studies are also underway for the construction of several nuclear-powered merchant ships.

Atomic Energy's Irradiation Work at Harwell, U.K.

Britain's Atomic Energy Authority Wantage Radiation Laboratories have expanded to a new unit at Harwell, where important research work in irradiation treatment including bulk sterilization of medical supplies is going on. Situated close to two of Britain's high-powered research reactors, Dido and Pluto, the building contains a deep stainless-steel-lined pool filled with water. Fuel elements are brought to the pool from the reactors when a predetermined amount of uranium fuel from them has burned out to allow the initial activity to die down before re-processing. The elements are still so radioactive that the shielded flask in which they are transported is equipped with a cooling device and a "wet cropper" machine is used to transfer the element from the flask to the pool. It "tops and tails" the fuel element and removes the nose and stalk which contain no active material. The active portion is placed in a cadmium sheath which stops all the neutrons emitted by the fuel but does not inhibit the gamma-radiation.

The pool is being used in a wide range of work for both medicine and industry. One example of the latter is radiation treatment of polyethylene to raise its softening point. Also, companies which are to produce lubricants for the Central Electricty Generating Board nuclear power plants are having sample greases irradiated.

California Institute Computer Centre

A Burroughs 220 electronic computer system has been installed at California Institute of Technology as the central unit of their remodelled computer centre. Satellite orbit calculations, simulation of brain functions and calculations of the rate of expansion of the universe are but a few of the uses to which the new computer will be put. It is capable of 300,000 additions or subtractions per minute, and includes a data processor unit, a 55,000 digit magnetic core memory, paper tape input-output units and two magnetic tape auxiliary storage units. Expansion can be made to include an additional 55,000 digits of main memory and eight magnetic tape auxiliary storage units.

Two analog computers are also being installed in the Caltech facilities which have been developed by their own Analysis Laboratory. The basic data derived from these computers will be processed and evaluated by the 220.

L. A. Dubridge, Caltech president, has said, "This new discipline promises to have a profound impact not only on science and technology but on our ability to train and educate creative thinkers in all fields of endeavor."

Australian Travelling Gantry Crane

A 110-ton travelling gantry crane is being operated at the Keepit Dam construction site by the Water Conservation and Irrigation Commission on the Namoi River in New South Wales. The electrically operated crane is required to transfer the 53 ft. x 38 ft. bulkhead gate from its storage postion to any of the six spillway openings in order to protect the radial gates in the event of an emergency and to allow service on these gates. Auxiliary hoists, traversing at right angles to the axis of the dam, are also being used to handle fixed wheel gates and hoists, radial gate hoists, trash racks, cover slabs and other miscellaneous equipment normally located on or below the crest of the dam.

The main hoist lifts a 110 ton load at a rate of 3 ft. per minute, while the auxiliary hoist lifts 5 tons at 25 ft. per minute and loads ranging from 13 to 25 tons at 15 ft. per minute, depending on the position of the load in relation to the axis of the dam. The traversing of the erane and bulkhead gate along 750 ft. of straight track on the crest of the dam is at a maximum speed of 30 ft. per minute. A trailing cable laid on the crest of the dam brings power to the crane.

• CANADIAN DEVELOPMENTS

(*Continued from page 91*)

effected on April 18. Previously the two governments had agreed to give sympathetic consideration to representations concerning implementation of the specific trade agreement. However, the scope for such representations has been enlarged to include any other matters affecting commercial relations between the two countries. Canada could thus, should the need arise, take up with the government of the USSR any special problems concerning the sale in world markets of Soviet products in which Canada has a substantial export interest. Soviet foreign trade organizations will purchase Canadian goods up to a total value of $25 million Canadian provided the total annual value of Canadian purchases from the USSR is not less than $12½ million.

Three Northern Stations for Ontario Hydro

Ontario Hydro is planning a six-year, $182,000,000 construction program in the James Bay watershed involving three new generating stations and North Ameriea's first 460,000 volt transmission line. The station construction will be on the Mattagami River, west of Kapuskasing and Moosonee. The southernmost plant, at Upper Long Rapids, will be completed in 1963 with an initial capacity of 114,000 kw. By winter of 1965 a second station at Upper Long Rapids will be generating 110,000 kw., while the third, of 132,000 kw., at Lower Long Rapids, will be ready for operation in 1966.

Gas Turbines for Quebec

Hydro Quebec has ordered six 6,000 kw. gas turbine generator units from Canadian General Electric. They are to be located at the Commission's substation at Les Boules on the Gaspe peninsula, serving as a standby plant, a peak plant (to add to the supply available from the underwater cables), and a synchronous condenser plant to promote ideal operating conditions.

University of Waterloo to Build $2 Million Engineering Building

Work will begin this Fall on a 133,000 sq. ft. engineering building at the University of Waterloo, according to a recent announcement by Dr. J. G. Hagey, president of the university. The estimated cost is $2 million.

The civil, electrical and mechanical engineering departments will be housed in the new building which is to be composed of three sections—a three-storey classroom and laboratory wing, a one-storey, high-ceiling heavy laboratory wing and a two-storey office wing.

The design of the building will be harmonious with the adjacent chemistry and chemical engineering building and the physics and mathematics building. The three buildings will form a quadrangle to make up an engineering and science cell on the 210 acre campus of the new university.

The engineering and science cell is the first phase in the development of a 65 acre area of teaching buildings. Campus development plans call for three cells—one of general science buildings, one of the arts buildings and the third of joint-use buildings such as the library, administration building, student union and convocation hall.

Award to Seaway and Power Project

The American Society of Civil Engineers' 1960 Outstanding Civil Engineering Achievement Award was presented to the St. Lawrence Seaway and Power Project in a ceremony at the Power Project, May 19. Representatives from the Power Authority of the State of New York, the Hydro-Electric Power Commision of Ontario, the St. Lawrence Seaway Authority and the Saint Lawrence Seaway Development Corporation were present for the occasion.

Whiteshell Nuclear Research Establishment

Eleven thousand acres of land 60 miles east-north-east of Winnipeg have been selected by Atomic Energy of Canada Ltd. for Canada's second nuclear research centre. Although the centre will start as a small unit, it is expected to expand as nuclear research develops, perhaps even to the dimensions of the Chalk River plant. The new development is to be known as the Whiteshell Nuclear Research Establishment as it will be located close to the Whiteshell Forest Reserve. Some work will be done on the site this summer. However, the major construction work will not start until 1961.

It is likely that AECL will install an organic cooled, natural uranium fuelled, heavy water moderated reactor at this site as its next major research project. Close liaison has been set up between AECL and the Manitoba Development Authority. Plans for a residential area are under study.

Month to Month

Supply and Demand Situation for 1959 Graduates

The annual *Bulletin on the Supply and Demand Situation in Regard to University Graduates for 1959*, issued by the National Employment Service of the Unemployment Insurance Commission, shows that the prospects for well-trained university graduates remain good. The demand for engineering graduates is great and yet enrolment fell off temporarily in the Fall of 1959 presumably due to adverse developments in the aircraft industry in Canada.

Employment vacancies for engineering graduates in 1959 numbered 1,597, with the majority of jobs in civil engineering. Mechanical, electrical and chemical were next in that order. Although the rate of increase in total employment was below the 1957 peak, it was still high. Construction and business service industries, colleges and universities, and government agencies were the exceptions, their rates of increase remaining about the same.

A survey conducted in late 1959 by the Federal Department of Labour revealed that 80.3% of all hirings of engineering, scientific and architectural personnel during the years 1956-57 were of either new graduates or experienced Canadian personnel. Only 13.5% of those employed were immigrants already in Canada; only 6.2% were obtained from outside the country.

Recruiting Practices and Procedures

The American Society for Engineering Education has recently published a brochure entitled "Recruiting Practices and Procedures, 1959". Its stated purpose is to "aid in the development and maintenance of high ethical standards in the procedures of college recruiting and in the relations between the employing organizations, college authorities, and college students who are engaged therein."

Recruiting of college students should be carried out to serve best the following objectives:

1. To promote a wise and responsible choice of career by the student for his own greatest satisfaction, minimum wasteful turnover and most fruitful long term investment of his talents for himself, his employer and society.
2. To strengthen in him a high standard of integrity and a concept of similar standards in the employing organizations of the country.
3. To develop in the student an attitude of personal responsibility for his own career and advancement in it, based on performance.
4. To minimize interference with the educational processes of the college and to encourage completion of the individual's plans for further education.

Practices and Procedures: Responsibilities of the Employer:

1. The employer should contact the Placement Office well in advance regarding interview dates, broad categories of work expected to be available, college degrees and other pertinent requirements.
2. The employer should supply adequate literature to give the student a fair picture of the employing organization.
3. When both the parent organization and subsidiary or affiliated organization conduct interviews in the same college, the respective interviewers should explain their missions and connections, both to the Placement Office and to the students.
4. Not more than two and preferably only one interviewer representing an employer should appear for each interview schedule. Arrangements for more should be made with the Placement Office.
5. The Placement Office should be advised in advance of any plans for campus visits by the representatives of an employer, including alumni of the college.
6. An employer who desires to contact an individual student at the time of his interview visit should communicate with him well in advance and notify the Placement Office.
7. The interviewer should clearly explain to the Placement Office and students any special requirements such as the passing of tests, physical examinations, signing of parent agreements, or if his job is affected by any union contract.
8. The interviewer should be punctual and make every effort to avoid last minute cancellations.
9. The interviewer should be careful to follow the time schedule agreed upon with the Placement Bureau.
10. As soon as possible the interviewer should communicate with the Placement Bureau and student regarding the outcome of an interview.
11. The employer should give the student reasonable time to consider his offer, and in no case should the student be pressured into making a decision regarding employment.
12. If the employer invites the student to visit his premises for the purpose of further discussion of employment, the visit should be arranged to conflict as little as possible with class schedules.
13. The employer should not offer the student any special gifts or inducements.
14. Employers should not raise offers already made except when such action can be clearly justified as sound industrial relations practice, such as when an increase in hiring rate is required on an overall basis to reflect salary adjustments.
15. The employer should keep the Placement Bureau informed concerning his interest in particular students and his negotiations with them.
16. When a student has declined a job offer, the employer should accept the decision as final.
17. The employer should engage each student who has accepted his offer except when failure to do so is the direct result of contingencies explained in the interview or unavoidable economic factors not foreseen when the offer was made.

Responsibilities of the College:

1. As part of its general obligation for the development of the student, the college should accept responsibility for stimulation of his thinking about his career objectives and for assistance in overcoming handicaps which may hinder his progress toward objectives appropriate for him. Competent counseling services should be provided for this purpose.

2. The Placement Office should inform employers concerning the number of students available for interview in the several curricula, and the dates of graduation.

3. The Placement Office should announce to students early in the school year which employers will interview students and when.

4. The Placement Office should make employment literature available to students and faculty.

5. When an employer is looking for graduates in several fields (e.g. engineering, psychology, physics) the Placement Office should issue announcements to all qualified students concerned.

6. The Placement Office should not restrict the number of interviews per student, except as necessary to discourage indiscriminate "shopping."

7. The college should provide adequate space and facilities for quiet and private interviews.

8. The Placement Office should provide interviewers with available records of those students in whom they are interested.

9. The Placement Office should arrange for interviewers to meet faculty members who know students personally and can provide information about their work and qualifications.

10. The Placement officer and faculty members should counsel students but should not unduly influence them in the selection of jobs.

11. The Placement Office should make certain that students are acquainted with this statement of "Principles and Practices of College Recruiting."

Responsibilities of the Student:

1. In seeking company interviews, the student should recognize his responsibility to analyze his interests and abilities and consider carefully his career objective and appropriate ways of meeting it. He should read available literature and consult other sources for information about the employer and organize his thoughts in order that he may intelligently ask and answer questions.

2. The student should contact the Placement Office well in advance regarding desired interviews or cancellations.

3. The student should use care in filling out such forms as may be requested in preparation for interviews.

4. In his interviews, the student should recognize that he is representing his college, as well as himself, and should be punctual and thoroughly businesslike in his conduct.

5. The student should promptly acknowledge an invitation to visit an employer's premises. He should accept an invitation only when he is sincerely interested in exploring employment with that employer.

6. When a student is invited to visit an employer's premises at the employer's expense, he should include on his expense report only those costs which pertain to the trip. If he visits several employers on the same trip, costs should be prorated among them.

7. As soon as the student determines that he will not accept an offer, he should immediately notify the employer.

8. The student should not continue to present himself for interviews after he has accepted an employment offer.

9. Acceptance of an employment offer by the student should be made in good faith and with the sincere intention of honoring his employment commitment.

10. The student should keep the Placement Office advised concerning his employment negotiations in accordance with the policy of his Placement Office.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on February 20, 1960.

Member: T. N. Arnold, Ottawa; P. J. Carson, Montreal; A. S. Coghill, Kingston; E. A. Dahl, Montreal; E. R. Dixon, Dundas; F. Engelhart, Montreal; D. A. Fraser, Copper Cliff; S. F. Franks, Ghana, Africa; S. K. Garg, Cornwall; F. S. Hummel, Toronto; P. T. Mitches, London; D. J. Moon, Toronto; E. R. Needles, New York; R. Patel, Ottawa; E. E. Paul, New York; J. G. Pierce, Peterborough; R. P. Preston, Montreal; U. R. Sainani (Mrs.), Montreal; J. A. G. Sneddon, Hamilton; S. Snell, England; E. K. Timby, New Jersey; H. M. Treleaven, Lockerby; P. W. Voisey, Montreal; R. Weir, Toronto; C. E. Welsh, Toronto; D. G. Wilson, Montreal.
Junior: G. N. Gillund, Chalk River; W. C. Gobel, Cornwall; L. B. Malone, Temiskaming.

Junior to Member: G. M. Boissonneault, Montreal; I. M. Campbell, Prince Rupert; G. Charlap, Sudbury; W. J. Cosgrove, Montreal; T. G. Cundill, Colborne; J. D. Denovan, Montreal; G. L. Genest, Ottawa; R. W. Lockie, Victoria; G. D. Mackay, Montreal; A. D. McDonald, Rexdale; W. Pegusch, Vancouver; F. A. Pike, Vancouver; G. L. Roy, Montreal; I. Waterlow, Trail; J. M. White, Ottawa.

STUDENTS ADMITTED

University of Manitoba: R. A. Anderson, W. H. Antonyshyn, J. S. Archer, A. J. Arenson, R. I. D. Barton, L. T. Baydack, F. O. Best, A. G. Bolton, G. M. Cederwall, K. M. Drennan, E. W. Dutchak, N. W. Emslie, S. Freitag, K. J. Gowriluk, R. E. Greenlay, H. M. Holroyde, C. W. Jack, M. Jacobs, W. W. Jonasson, W. H. Kauk, R. J. Keltie, S. J. Kopec, V. Lysack, J. P. Masserey, J. McBride, R. R. McKibbin, R. B. Robertson, E. G. Robins, D. Sader, C. T. Smith, D. W. Snaith, B. F. Thompson, H. E. Wackman, J. S. Websdale, R. B. Williams, L. S. Willison, P. B. Winslow, E. A. Zaleski.

University of Toronto: N. E. Anderson, R. F. G. Baker, P. M. Bishop, J. S. Brooks, N. C. Chaggares, W. R. Collard, J. Ezyk, W. A. Gibson, H. D. L. Gordon, R. A. Guerriere, A. L. Hidi, S. R. Hiseler, I. Holubuc, J. T. Jacobs, B. M. Johnson, T. W. Kolator, J. W. A. Maxwell, W. D. Medweth, J. R. Millar, J. H. Moylan, E. T. Perchyshyn, E. J. Rosseter, D. P. Rutenberg, A. W. Spary, J. M. Toohey, J. T. Unsworth, E. P. Wasylwic, T. A. Woods.

Carlton University: J. R. Barclay, J. N. Beshara, J. R. Bethell, D. A. Brown, E. P. Edelson, D. R. Enns, W. K. Glennie, D. A. Long, J. H. McCalla, A. J. McCann, G. A. McInnes, D. R. Moore, D. G. Munro, J. M. Roll, G. H. Saunders, R. A. Spittall, K. Stoodley, W. E. Stratton, L. Tannis, A. R. Thompson, R. H. Verner, W. G. G. Welsh, J. A. Wrinch.

McMaster University: T. Arciszewski, J. G. Brown, M. B. Carver, P. F. Crath, G. Crouch, D. E. Filman, R. J. Hick, R. J. Kulperger, H. Muzyka, D. B. Rehberg, W. V. B. Reist, G. E. Riley, I. B. Webster, W. Wlisko.

University of Alberta: L. A. Anderson, J. Audia, D. L. Baycroft, N. R. Burroughs, C. C. Fortems, R. S. French, R. A. Heise, J. V. Krupa, J. H. Moore, N. A. Patterson, V. J. Prystawa, P. L. Strohschein, W. Y. Svrcek.

University of British Columbia: L. A. Bergman, D. G. MacDonald, R. A. MacDonald, A. A. Offenberger, E. H. Plato, C. Ramjit, G. D. Rogers, C. Turner, W. A. Walrond.

McGill University: E. A. Adegeye, S. O. Alu, R. E. Amy, M. C. Brown, R. M. Cleary, H. G. Harris, G. J. Hazan, T. H. Moffet, R. F. Neill.

Royal Military College: R. B. Blake, M. G. Corbett, E. E. Goski, J. J. D. Lawson, M. A. S. MacNamara, H. J. Riva, W. N. G. Robinson, B. L. M. Smith, J. F. L. Tremblay.

Saint Mary's University: C. E. Blackie, D. A. Grantham, R. K. Kilvert, J. W. Macdonald, W. G. Spruin, E. J. Thimot.

Nova Scotia Technical College: J. P. Chisholm, R. L. Lathangue, B. P. MacDonald, J. L. MacDonell, G. C. Power, T. R. F. Prescott.

Memorial University: H. Bowering, W. W. Johnston, W. P. Doyle.

Mount Allison University: A. J. McGraw, J. R. Trenholm.

Ontario Agricultural College: P. D. Bright, H. T. Seymour.

St. Joseph's University: J. R. Arsenault, J. S. Terris.

Sir Geo. Williams University: D. C. Hutchinson.

Queen's University: J. A. Choma.

University of Western Ontario: R. J. Janssens.

University of Saskatchewan: M. B. McCurdy.

Acadia University: W. L. DeWolfe.

University of New Brunswick: P. R. Stewart.

Student of C.P.E. Quebec: G. Lapointe.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective.

ALBERTA

Members: W. H. Crowe, C. B. Dibblee, R. W. Gowswell, G. T. Narfason, P. Kolozs, G. R. McAthey, G. L. Williams, S. G. Cowan.
Junior to Member: J. A. Kerr, N. Malychuk.

SASKATCHEWAN

Members: A. P. Belyk, D. R. Brodie, D. S. Cathcart, J. L. D. Cooper, D. H. Filson, R. H. D. Grace, R. D. MacLean, R. V. Milne, W. J. Pearson, A. B. Webb, H. J. Wolbeer.
Junior: H. F. Button.
Junior to Member: G. F. Cox, V. J. Gross, D. M. J. Kent, N. L. King, T. W. McDonald, J. P. F. Mooney, R. H. Russell, E. M. Toth.
Student to Junior: R. A. Baumgartner, R. E. Beveridge, K. Birch, J. W. Rittinger, R. G. Sanders, A. T. Torgrimson.
Students: D. C. Ayotte, J. L. Barber, G. Bender, C. J. W. Biss, M. J. Blackwell, R. E. Bodnar, W. R. Brooks, A. M. Bryski, E. F. Cairns, G. Campbell, D. J. Cartwright, N. Chorney, R. B. Clunie, W. E. Culham, M. T. Dagg, R. E. Dart, R. H. David, D. P. Dean, A. G. DeJager, G. R. Demetrick, N. L. Derksen, A. E. Douglas, J. O. Edler, J. M. Ewart, T. W. M. Field, L. E. Fish, D. P. Foley, R. T. L. Froc, W. J. Gogol, W. A. Gold, T. P. Griffin, R. M. Halko, L. J. Hamblin, T. I. Hellquist, G. K. Hendriksen, M. J. Herasymuik P. B. Hertz, J. P. Hutch, W. G. Irvine, V. J. Isaak, M. W.

(Continued on page 101)

A.E.L. design engineers build a new bomb

FOR THE FIGHT AGAINST CANCER

"But can you design and build such a unit?" The speaker was an eminent specialist in cancer therapy at the Montreal General Hospital. The need was urgent. Existing X-Ray equipment for radiation treatment of cancer was expensive to maintain and cumbersome to manipulate. Research had indicated that the radioactive isotope Cesium 137 had excellent potential in cancer therapy and could, if properly harnessed, form a replacement for the 250 KV X-Ray machine and provide up to fifteen or twenty years of trouble-free life.

A. E. L. took up this vital challenge with enthusiasm. Working as a team with the Hospital specialists, A. E. L. engineers laid the foundations of a new design concept. A machine to treat every part of the human anatomy. To accomplish this two interchangeable fully adjustable collimators were produced. One, a continuously variable circular field 'Flexi-collimator' for head and neck treatment and, the other, a square field collimator for trunk and other work. In other words two diverse fields covered by one machine—a feat never before achieved in high intensity radiation therapy with only two collimators.

The Cesium Radiation Teletherapy Unit is now installed in the Montreal General Hospital and medical science has another weapon in the war against cancer.

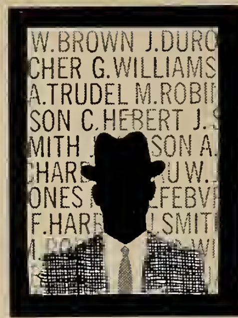
Another instance of how A.E.L.'s skills in research, design, engineering and manufacture are helping to solve problems in a wide range of industries. Your enquiries are invited.

AVIATION ELECTRIC
LIMITED

200 Laurentien Blvd., Montreal, P.Q.

Branch Plant: Aviation Electric Pacific Limited, Vancouver Airport, Vancouver, B. C.

Personals



Richard L. Hearn, Hon. M.E.I.C., (Toronto '13), Director, Atomic Energy of Canada Ltd., has been elected an honorary member of Britain's Institution of Electrical Engineers. The award is for "notable contributions in the development of electricity generation and its supply for the benefit and use of mankind, particularly in Canada, and for the part he has played in international co-operation in this field".

R. L. Hearn, Hon. M.E.I.C.

J. E. Neilson, M.E.I.C. (Queen's '28) was recently elected president and chief executive officer of Foster Wheeler Ltd., St. Catharines, Ont.

H. R. Montgomery, M.E.I.C. (McGill '29), of the Pentagon Construction Company, Montreal, has been elected a vice-president of the Canadian Construction Association. **G. R. Stunden**, JR.E.I.C. (McGill '50), of the Atlas Construction Company, Montreal, is the new chairman of CCA's Road Builders and Heavy Construction Section. **H. J. Leitch**, M.E.I.C. (McGill '26), of the Dominion Bridge Company, Montreal, is chairman of the trade contractors section and **A. W. Purdy**, M.E.I.C. (Queen's '49), of the Canada Cement Company, Calgary, is chairman of the manufacturers and suppliers section. CCA provincial vice-presidents include **H. W. Hilsden**, M.E.I.C. (Saskatchewan '50), of Hilsden & Company, Regina, for Saskatchewan and **R. H. Ansley**, M.E.I.C. (Manitoba '42), of Commonwealth Construction Company, Vancouver, for B.C.

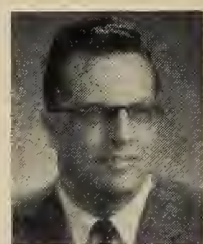
P. D. Dalton, M.E.I.C., (McGill '28), of Dalton Engineering and Construction Company, Toronto, is honorary secretary.

Ralph R. Willis, M.E.I.C. (New Brunswick '31) has been appointed vice-president and general manager of Ross Engineering of Canada Ltd.

G. B. Williams, M.E.I.C. (Manitoba '35), chief engineer of the Department of Public Works development engineering branch, has been selected to fill the new post of Assistant Deputy Minister (Technical), Ottawa. The position has been created to facilitate the Department's handling of technical responsibilities in the engineering and architectural fields.

Harry Jomini, M.E.I.C. (Manitoba '35) has been appointed director of public relations and advertising for the Aluminum Company of Canada in British Columbia.

A. D. Burford, JR.E.I.C. (Manitoba '54) has been appointed to direct the sale of electric and electronic products for Ward Leonard of Canada, Ltd., Toronto.



A. D. Burford, JR.E.I.C.

George P. Hobbs, M.E.I.C. (McGill '40) is the new head of Bowaters Engineering and Development Inc. at Calhoun, Tenn. Mr. Hobbs thus becomes head of the central engineering and research activities of the Bowater Organization in North America.

Walter G. Ward, M.E.I.C. (McGill '42), vice-president and general manager of the apparatus department of the Canadian General Electric Company, has been named president of the Montreal Armature Works Ltd., a company recently purchased by CGE.

L. P. Dancose, M.E.I.C. (Ecole Polytechnique '42), chairman of the Lower St. Lawrence Branch, has been appointed superintendent of buildings, vehicles and supply at the Quebec Telephone Company.

W. D. Stothert, M.E.I.C. (Alberta '45) has been appointed manager of engineering, maintenance, utilities, purchasing, stores, and traffic at the Columbia Cellulose Company Ltd.'s Watson Island dissolving grade pulp mill, Prince Rupert, British Columbia.

Ralph E. Crysler, M.E.I.C. (Toronto '49), **Clark B. Davis**, JR.E.I.C. (Toronto '50), and **Eric G. Jorgensen**, M.E.I.C. (Queen's '49), formerly of the firm of H. A. Babcock & Company Ltd., have opened a new firm of consulting engineers under the name of Crysler, Davis & Jorgensen, Ltd. in Willowdale, Ont.

R. C. McMordie, M.E.I.C. (Toronto '30) is chairman of the recently organized Senior Staff Executive Committee of the B.C. Power Commission which replaces the post of General Manager in the Commission. Mr. McMordie has also been made Manager of Engineering and Operations and Chief Management Officer for the Commission. **A. J. G. Leighton**, M.E.I.C. (Saskatchewan '42) has been appointed Director of Engineering. **P. J. Croft**, M.E.I.C. is the new Director of Planning

C. Albright, M.E.I.C. (Manitoba '50) has been named Maintenance Superintendent for the Phosphate Plant at the Consolidated Mining and Smelting Company of Canada Ltd., Trail, B.C. **W. A. Cairns**, M.E.I.C. (Alberta '36) is the Superintendent of Cominco's new Chlor-Alkali Department.

Jean-R. Cote, M.E.I.C., consulting engineer at Rouyn, Quebec, has been named local representative for Mr. Auguste Martineau, architect, Ottawa.

W. A. Ketchen, M.E.I.C. (McGill '28) was recently appointed vice-president, technical services, of Fraser Companies, Ltd. in Edmundston, N.B.

W. A. Ketchen, M.E.I.C.

L. H. Lafontaine JR.E.I.C. (Reusselaer Polytechnic Institute '53) has been appointed to direct the sales of heat exchangers for the recently established boiler products division of the Dominion Bridge Company Ltd. in Montreal. **Neil Richards**, Jr. E.I.C. (Manitoba '56) has been named sales representative for Alberta, operating from the company's Calgary branch.

Wide open spaces...

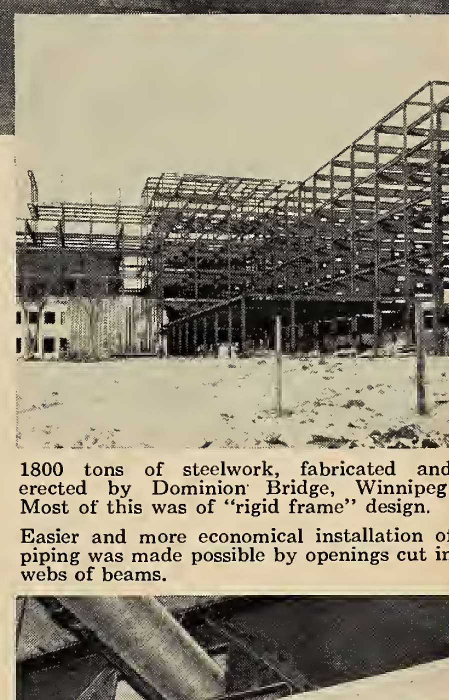
You get space, speed, flexibility and economy with steel construction—all were achieved in the Great West Life Assurance Company's new head office building in Winnipeg.

The use of long span steel beam construction gave large column free areas and allowed maximum flexibility of interior partitioning. Future changes in office and space requirements can be easily accommodated.

In addition, openings in the beam webs provided for passage of electrical, plumbing and heating facilities beneath the floor—without adding to the building's over-all height. Every inch saved in height meant significant dollar savings.

All the steelwork was erected during three months of bitter winter weather. This enabled the sub-trades to move in on time to complete their work.

Architects: Marani & Morris of Toronto and Moody Moore and Partners of Winnipeg. Consulting engineers on structural design: Wallace, Carruthers & Associates of Toronto. Contractor: G. A. Baert Construction Co. Ltd.



1800 tons of steelwork, fabricated and erected by Dominion Bridge, Winnipeg. Most of this was of "rigid frame" design.

Easier and more economical installation of piping was made possible by openings cut in webs of beams.

39

structural steel by

DOMINION BRIDGE

FOURTEEN PLANTS—COAST-TO-COAST

J. R. McGovern, JR.E.I.C. (McGill '51) has been elected vice-president and general manager of Sola Electric (Canada) Ltd. Re-elected to the company's board of directors, Mr. McGovern will also be in charge of operations of the company's Toronto plant.

Fritz Rumscheidt, JR.E.I.C. (McGill '56), a postgraduate student at the Pulp and Paper Research Institute of Canada, has been awarded the Spruce Falls Power and Paper Company Ltd. Fellowship for the academic year 1959-60 at McGill and PPRIC.

J. S. Kendrick, M.E.I.C. (British Columbia '38), formerly with the Aluminum Company of Canada, has been appointed a Vice-President of Sandwell International Ltd., Consulting Engineers, in Vancouver.

Terence J. Farrell, M.E.I.C. (Manchester University) has been appointed manager of plate and mechanical sales for Canadian Vickers Ltd., with headquarters in Montreal.

Paul E. Paquin, M.E.I.C. (McGill '40) has been promoted to the position of Manager, Electric Welding Division, of the Canadian Liquid Air Company Ltd. He was formerly Manager of Electric Welding Sales.

D. F. Rankine, M.E.I.C. (Manitoba '47) has been named vice-president and manager of Montreal Armature Works Ltd. The company is owned by the Canadian General Electric Company Ltd.

Donald H. McLeod, JR.E.I.C. (Saskatchewan '50) has been named associate-in-charge of the Brandon, Manitoba office of Ward and Macdonald Associates, architects. He will be responsible for the supervision of the firm's projects in Western Manitoba.

R. H. Hall, M.E.I.C., (Saskatchewan '41) has been appointed assistant to the vice-president, research and development of Shawinigan Chemicals Ltd. and has been elected to the board of directors of B.A.-Shawinigan.

N. M. McCallum, M.E.I.C. (British Columbia '23), formerly manager of General Construction Company (Alberta) Ltd., Lethbridge, has joined Willis & Cunliffe Engineering Ltd., Victoria, as a director of the company and chief engineer.

Walter Murray, M.E.I.C. (Edinburgh '26), formerly engineer of Pointe Claire, Quebec, is the new town engineer of Trenton, Ontario.

We offer our apologies to Dr. R. R. Jackson, M.E.I.C. (Alberta '44), formerly associated with the Radio and Electrical Engineering Division of N.R.C., who is at present a Fellow Engineer in the New Products Department of the Westinghouse Electric Corporation, Cheswick, Pa. The Mussens Canada Ltd. appointment attributed to him in the February issue was incorrect.

Roy C. P. Preston, M.E.I.C. (Toronto '50) has been appointed sales manager in the road building materials division of The Pedlar People Ltd. He will be located at the Oshawa head office of the company.

Alec Coghill, M.E.I.C. (Queen's '51) has joined The Aluminum Company of Canada, Ltd., Kitimat Works. Works as metallurgist in the Technical Division.

C. J. MacHutchin
JR.E.I.C.

G. J. MacHutchin, JR.E.I.C. (McGill '52) has been elected president of the Duron Company, Ltd., specialists in epoxy flooring, Montreal and Toronto.

H. B. Tafelmacher, M.E.I.C. (Zurich '46) was recently elected Managing Director of Aluminio del Uruguay, S.A., a producer of aluminum sheets and sections in Montevideo, Uruguay.

Jules J. C. Picot, JR.E.I.C. (N.S.T.C. '55), formerly with the Bathurst Power and Paper Company Ltd., Bathurst, N.B., is now a member of the faculty of the Chemical Engineering Department at the University of New Brunswick.

MONTH TO MONTH

(Continued from page 96)

Janzen, K. B. Jarvis, R. S. Jickling, L. P. Jonassen, T. L. Kaminski, A. E. Keller, H. A. Kerr, J. E. Kerr, E. W. Kindrachuk, G. C. Koch, S. L. Koroluk, R. A. Kuchinka, L. J. Lambie, R. C. Landine, R. G. Lawrence, K. A. Lenz, A. P. H. Li, A. P. Livingstone, B. A. Lundeen, J. E. MacDonald, W. S. MacDonald, C. S. Mackay, C. L. Marshall, D. I. Mason, D. H. McGladdery, R. T. McLean, L. K. McMillan, R. G. Mickleborough, R. O. Mickleborough, V. E. Moneo, G. N. Negraiff, Newoso, A. F. J. Newton, J. A. Nightingale, E. O. Nyborg, A. R. Otterdahl, R. C. Parkinson, A. G. A. Pearson, O. P. Pederson, A. Pehl, V. P. Peters, B. Pidlisecky, S. W. Porter, D. E. Pufahl, S. B. Rapaport, J. T. Rees, T. W. Rey, R. C. Reynaud, R. A. Robertson, V. M. Sadowick, W. Sawchuk, G. W. Schindel, L. D. Schnell, R. L. Searcy, R. H. Shaw, J. Shewchuk, J. Shyluk, D. E. Sillars, A. Sippola, R. E. Sjoberg, B. L. Smith, A. J. Solie, G. E. L. Sorli, K. Stenbraaten, S. S. Strilchuk, G. L. Thamer, D. A. Thies, J. W. Thiessen, P. E. Timm, J. Tooth, E. C. Turgeon, R. J. Turner, L. J. Tusz, H. Tysseland, M. J. Visser, D. H. Werle, J. A. Widger, E. H. Wiens, V. H. Wiens, D. A. Wilde, A. E. Willard, L. E. Wilson, M. C. Wilson, W. A. Wristen, J. S. Yannikostas, L. Zarusky, W. A. Zrymiak.

NOVA SCOTIA

Members: A. M. Garbary, J. W. Lindsay, R. C. Nolan, J. L. O'Toole, J. A. Parker.

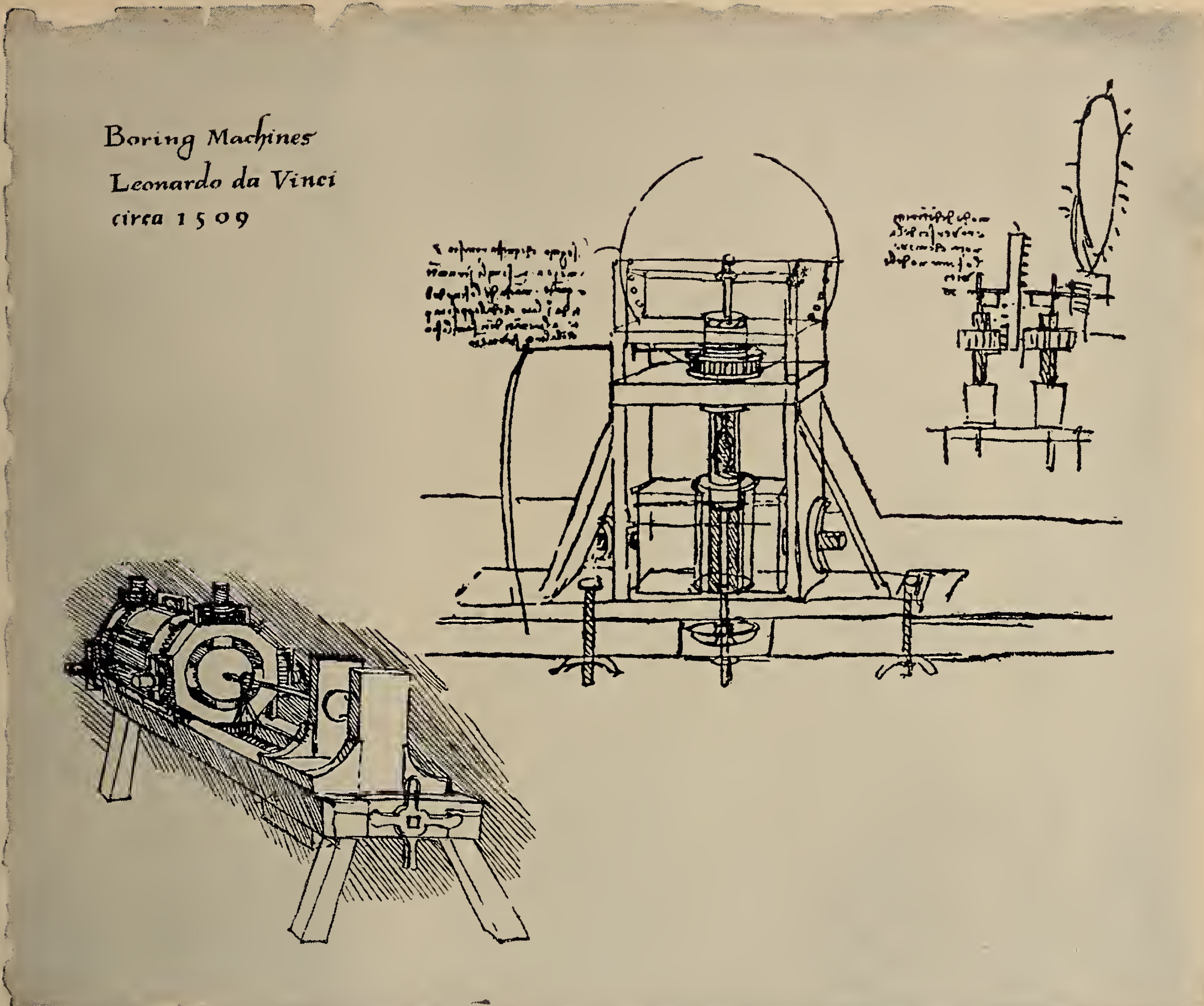
NEW BRUNSWICK

Member: G. N. Langley.

MANITOBA

Members: K. Hallson, L. M. Harrs, G. A. Muir.

Junior to Member: F. G. Denson, G. C. March.



LEONARDO DA VINCI, *in addition to being an artist, engineer, and inventor, was also a superb craftsman. Reproduced here are original sketches by Da Vinci of boring machines—one for boring cylinders, the other featuring a unique self-centering device.*

CRAFTSMANSHIP

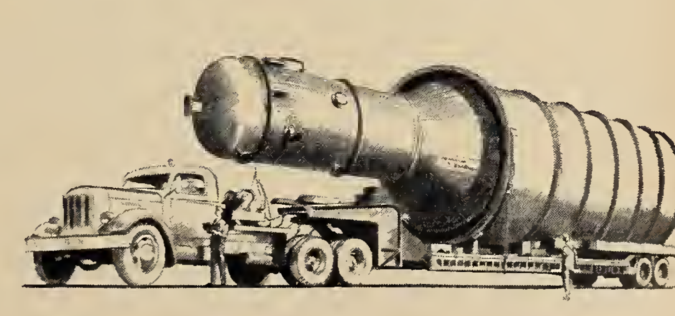
Illustrated below is a giant vacuum column used in oil refinery operations. This is a typical example of the fine craftsmanship and many sided skills demonstrated by Canadian Vickers in the manufacture of all types of petro-chemical equipment.

In their plants, Canadian Vickers also design and manufacture machines, both large and small, and equipment for every imaginable industrial need . . . thereby fulfilling their pledge: "If Industry Needs It . . . Canadian Vickers Builds It . . . Better."

Industrial Boilers • Chemical Process Equipment • Hydraulic Machinery • Ships
Special Machinery • Marine Equipment • Pulp and Paper Plant • Mining Machinery

CANADIAN VICKERS LIMITED

MONTREAL • TORONTO
MEMBER OF THE VICKERS GROUP



50-ton vacuum column with overall length of 74 ft., built by Canadian Vickers for a Canadian oil refinery.

Obituaries

George E. Baldry, Affil. E.I.C., died in St. Norbert, Manitoba on October 17, 1959. He was 75.

Born in Osgoode Station, Ontario, Mr. Baldry went to Winnipeg in 1906.

He was president of the Baldry Engineering and Construction Company at the time of his death.

George E. Baldry
Affil. E.I.C.

Stanley H. Cunha, M.E.I.C., senior employee of the Quebec Hydro-Electric Commission died, on March 21, 1960. Mr. Cunha was a Life Member of the Institute.

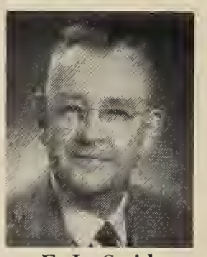
A native of Kingston, Jamaica, Mr. Cunha came to Canada in his early years and graduated from McGill University in 1905.

Mr. Cunha worked many years for the Quebec Hydro-Electric Commission and, even after reaching the statutory retirement age, remained at Hydro-Quebec on a temporary basis to render his valuable services.

A contributor to engineering papers and magazines, Mr. Cunha helped to write several articles on engineering problems encountered in hydro-electric developments.

He was also a Life Member of the American Institute of Electrical Engineers.

A. Love
M.E.I.C.



E. L. Smith
M.E.I.C.

Alexander Love, M.E.I.C., consulting civil engineer, died in Hamilton, Ontario, April 7, 1960. He was a Life Member of the Institute.

A native of Scotland, Mr. Love emigrated to Canada in 1912 and resided in Hamilton from that time until his death. During the First World War he served with the 19th Canadian Infantry Battalion and later with the Canadian Engineers.

As secretary of the Hamilton Branch of the Institute from 1933 to 1936, and as chairman in 1940, Mr. Love enjoyed an active participation in Institute affairs. He was honoured with Life Membership in January, 1955.

Alfred LaBissonniere, Affil. E.I.C., died in Montreal on January 3, 1960. He was 60 years old.

Mr. LaBissonniere was educated at the College of Berthier and Lemmington High School in Ontario. He began his career on the Great Lakes boats, working for the Federal Government, in 1920. Six years later he joined the International Paper Company in Three Rivers, Quebec, and from 1926 to 1936 he studied to receive his first class certificate. In 1936 he became a boiler inspector for the Provincial Government, and from 1939 to 1945 he worked with the Royal Inspection Company.

Alfred LaBissonniere
Affil. E.I.C.

In 1945 Mr. LaBissonniere returned to the Provincial Government as assistant chief inspector and was appointed chief inspector in 1949.

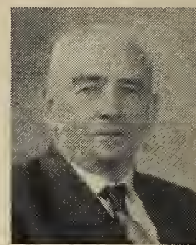
An Affiliate Member of the Institute, Mr. LaBissonniere was also a member of the National Board and of the American Society of Mechanical Engineers.

Eugene Lloyd Smith, M.E.I.C., 59, died in Edmonton on March 21, 1960. Mr. Smith had been assistant superintendent and chief chemical engineer at the Edmonton power plant for the last seven years, where he was in charge of water treatment.

Born in Wentworth, Nova Scotia, Mr. Smith received his education from the University of Alberta, graduating with a degree in chemical engineering in 1930. He joined the city power plant staff in 1935.

Mr. Smith, a director of the Western Canada Water and Sewage Conference, was considered Western Canada's outstanding authority on water treatment. He was a past president of the Edmonton Branch of the Institute and a member of the Dominion Council of Professional Engineers.

Under Mr. Smith's supervision, the Edmonton water treatment plant tripled its capacity during the past five years. Mr. Smith was also in charge of re-equipping the pumping station at the plant.



J. E. Underwood
M.E.I.C.

Joseph Edwin Underwood, M.E.I.C., a Life Member of the Institute, died in Saskatoon April 7, 1960, at the age of 77.

Until his retirement, Mr. Underwood was senior member of the engineering firm of Underwood, McLellan & Associates, Saskatoon. During his more than 45 years of business in that city he was associated with numerous major municipal engineering and surveying projects in northern Saskatchewan, and he was Mayor of Saskatoon in 1932, the year the Broadway bridge was built across the South Saskatchewan River.

A resident of Saskatoon since 1911, Mr. Underwood was born in Wroxeter, Ontario. He graduated from the University of Toronto with a degree in civil engineering in 1909. His first professional work was on surveys for the Federal Government in Western Canada. He later became resident engineer with McArthur and Murphy, Saskatoon. In 1911, associated with Murphy and Underwood, Mr. Underwood supervised the building of hydro electric plants and water systems at Wilkie and Scott, Saskatchewan. One of his larger undertakings was the complete modernization of the Flin Flon townsite in Saskatchewan.

From 1911 until his retirement in 1957, Mr. Underwood was associated successively with Murphy and Underwood, J. E. Underwood and Associates, Underwood and McLellan and Underwood, and McLellan and Associates. In 1952 Mr. Underwood and Mr. McLellan sold their interests in the firm but were retained in the firm as advisors.

A Member of the Association of Professional Engineers of Saskatchewan, the Canadian Institute of Surveying, the Saskatchewan Land Surveyor's Association, the Community Planning Association of Canada, and the town planning board of Saskatoon, Mr. Underwood also served on the execuitve of the Saskatoon Board of Trade.

Other Societies

Instrument Society of America - 1960 I. M. A. Symposium

A three-day symposium on Instrumental Methods of Analysis, arranged by the Montreal organization of the I.S.A., will be held at the Queen Elizabeth Hotel, Montreal, June 1-3. A technical program of more than 50 papers has been arranged and will feature recent developments in the field by a number of eminent international authorities.

Wednesday morning's sessions will be devoted to general topics, with the keynote opening address by Dr. O. Rademaker of Eindoven University, Holland.

The regular sessions, beginning on Wednesday afternoon, have been arranged in two simultaneous groups. While one's particular interests will guide the choice of group, they have been roughly separated so that those interested basically in processing may follow one program, while those interested basically in laboratory developments may follow the other.

Wednesday afternoon's sessions on "Medical Instrumentation" will be chaired by Dr. John F. Davis. The sessions on "Nuclear Instrumentation" will be chaired by Dr. W. H. Stevens. There will be a second session on "Medical Instrumentation" on Wednesday evening, featuring a panel discussion on Medical Analyzers.

On Thursday morning, Dr. P. H. Stirling will chair a group of papers on "Process Gas Chromotography," while W. Forsyth chairs a series on "Spectographic Analysis." In the afternoon Nathaniel Brenner will chair three papers and a panel discussion on "Gas Chromotography," and those interested in tours will be given an opportunity to observe some outstanding instrument installations in the vicinity of Montreal.

Friday morning's program consists of a series of papers on "Electrochemical Methods," chaired by T. S. Kehoe, and a series of papers on "Sample Handling," chaired by L. Maley. The speaker at the noon luncheon will be Dr. Leo Marion of N.R.C. The afternoon sessions are "Electrochemical Methods," chaired by P. W. Dufresne and "Physical and Chemical Methods," chaired by J. P. Strange.

A varied and interesting ladies' program has been arranged, and a number of mixed social functions have been scheduled.

This is the first time that a major I.S.A. technical conference on instrumentation has been held in Canada, and all engineers interested in the subject are urged to attend, whether or not they are members of the co-operating societies responsible for the meeting.

Advance registration is being carried out, and advance proceedings will be available at the hotel. Further inquiries regarding rates, hotel reservations, or details of program are available from:

Mr. N. B. Ward,
4060 MacKenzie Street,
Montreal 26, Que.
PHONE REgent 1-5257

1961 Congress on Large Dams

The 7th Congress of the International Commission on Large Dams will be held in Rome, June 26 through July 2, 1961. Questions for discussion include: the selection, processing and specifications of aggregates for concrete in large dams; underground work in connection with large dams; modern techniques of concrete dams for wide valleys and ancillary works; and sealing of earth and rockfill dams with bitumen and other materials. Following the Congress there will be tours of important dams in Italy. Participants will be in Europe in time to attend the 5th International Congress of Soil Mechanics and Foundation Engineering in Paris, July 17 to 22, 1961.

Anyone interested in the Rome Congress, or in contributing a paper, may obtain further information from: Mr. J. K. Sexton, vice-chairman, Canadian National Committee, ICOLD, c/o Canadian Electrical Association, 35 York Street, Westmount, Quebec.

American Society for Quality Control, Montreal Section

The Montreal Section of A.S.Q.C. held its elections on March 22 and voted into office for the 1960-61 term: chairman, Franklin Clow; vice-chairman, W. Wingfield; secretary, S. Thomas; immediate past chairman, D. W. Guthrie.

World Power Conference

The Madrid Sectional Meeting of the World Power Conference is to be held June 5 to June 9, 1960. Papers will be delivered on these subjects: Methods of Investigation of Energy Sources and Requirements; Efficiency of Production and Utilization of Energy; Technical Developments in Transportation; Establishment of Nuclear Reactors on an Industrial Scale; Functional Inter-Relation between Conventional and Nuclear Production of Energy.

The Associations and Corporation

The Annual Meeting of the Municipal Engineers' Division of the Association of Professional Engineers of B.C. will be held at the Trail Civic Centre, Trail, B.C. on September 15, 16 and 17. Convention chairman is J. F. Millican, Superintendent of Transportation for the Consolidated Mining and Smelting Company in Trail.

A special feature of the program this year will be a special two-hour session on the opening day in which the delegates will be divided into two groups to permit study of specific problems peculiar to professional municipal engineers in one group, and works superintendents and suppliers in the other.

Courses and Fellowships

The Isaac Wolfson Research Fellowship in Metallurgy is offered by St. Edmund Hall, Oxford, England, to applicants between the ages of 24 and 35 from the Commonwealth countries or Israel. Commencing October 1, 1960, the appointment is for three years' research in a field approved by the Isaac Wolfson Professor. It includes a stipend of approximately $2800, free accommodation or a housing allowance, and the whole or part of travelling expenses.

Applications should be sent to The Principal, St. Edmund Hall, Oxford, immediately. Candidates are asked to submit a detailed statement of career to date and of the research proposed, together with two references.

The **Ontario Traffic Conference** will present a series of traffic training courses from May 30 to June 10, 1960, in co-operation with Huron College and the University of Western Ontario, London. The tuition fee of $125 includes meals and accommodation as well as texts and manuals. The purpose of these courses is to provide a knowledge of the basic principles of traffic operation particularly related to Canadian municipalities.

The **Special Summer Program at the Massachusetts Institute of Technology** will include a course in Fundamentals of Adhesion from June 27 to July 1, 1960. The program will be presented by the M.I.T. Plastics Research Laboratory under the direction of Professor Albert G. H. Dietz, and the tuition will be $200. No academic credit is offered.

The **Management Development Center of the California Institute of Technology**, Pasadena, California, is sponsoring seven full-time conferences, four during the period June 19 to 24, and three from September 11 to 16. The conferences will be held on the Pasadena campus, and the fee per conference is $150 with a room charge of $20 per week. Topics for discussion include: supervision of engineers; supervision of technical sales personnel; wage and salary administration; older workers and retired employees; administering an executive development program; and managing office personnel and operations.

The **Fourth International Course on Hydraulic Engineering** will be given at Delft beginning in October 1960. Organized by the Netherlands Universities Foundation for International Co-operation, the eight-month course is for graduate engineers who are interested in one or a combination of its three branches of study; tidal and coastal engineering (including harbours); reclamation; rivers and navigation works (including ground-water recovery). Tuition is 2000 Dutch guilders, and the closing date for application is July 31, 1960. Further information can be obtained from NUFFIC, 27 Molenstraat, The Hague, Netherlands.

A new college, **The College of Advanced Science** has been established at Canaan, New Hampshire for the study of graduate physics and supporting subjects including mathematics and physical chemistry. At present, the college is accepting special students at any college level to study tutorially under Dr. Royal M. Frye, former chairman of the graduate school of physics, Boston University. However, when the full eight-quarter curriculum goes into operation, application will only be open to students with bachelors degrees.

The **British Council** is offering a course on Methods of Concrete Usage at University College, London, September 18 to 30, 1960. The purpose of the course is to supply overseas engineers with an up-to-date survey of methods of using concrete in England. Two days will be devoted to a visit at the Cement and Concrete Association's Research Station. Accommodation will be in London hotels and the fee, approximately $132.

The **Department of Engineering at the University of California** (Los Angeles) is offering three short courses in industrial photoelasticity and strain gauge techniques, August 15-19, August 22-26, and August 29 to September 2. For further information: Mr. Harold M. Kaysen, Engineering Extension, Department of Engineering, University of California, Los Angeles 24, Calif.

New Association of Urban Development Engineers

Convinced that the role of the consulting engineer in land development is here to stay, thirty Toronto engineers involved in land development activities formed an association in November 1959 known as the Association of Urban Development Engineers of Toronto. Membership is open to registered professional engineers who are principals of their firms.

A panel discussion among members of the township engineering staffs of Scarborough, North York, Etobicoke and New Toronto and Col. A. L. S. Nash of the Provincial Department of Planning and Development took place in Toronto on March 31 at the regular monthly meeting of the new association. Control on subdivision activities was the subject of the evening, and future meetings are planned for an exchange of information among others connected with subdivision development such as contractors engaged in sewer, water main and road construction and builders who take over lots and construct houses.

The following elected officers form the executive for 1960: president, R. V. Anderson; first vice-president, P. A. Monaghan; second vice-president, W. A. McArthur; treasurer, J. W. Setchell; secretary, R. E. Winter.

Coming Events . . .

May 23-26, 1960—Design Engineering Conference, New York Coliseum.

June 1—Industrial Education Institute Seminar. Theme: Locating and Developing Creative Engineers. Montreal (June 3—Toronto).

June 1-3—Annual ISA Instrumental Methods of Analysis Symposium, Montreal.

June 5-7—ASME Semi-Annual Meeting and Aviation Program, Dallas, Texas.

June 5-9 — World Power Conference, Madrid Sectional Meeting. Theme: Methods for Solving Power Shortage Problems.

June 13-15 — 43rd Canadian Chemical Conference and Exhibition of The Chemical Institute of Canada, Ottawa.

June 13-17 — Research Conference on Shear Strength of Cohesive Soils, University of Colorado.

June 25 to July 8—International Machine Tool Exhibition 1960, London.

June 27 to July 7—1st International Congress for Automatic Control (sponsored by AACC with ISA, ASME, AIEE, IRE and AIChE), Moscow.

June 26 to July 1—Annual Meeting of American Society for Testing Materials, Atlantic City.

July 21-27—Third International Conference on Medical Electronics and Associated Scientific Exhibition, London.

June 20-24—American Society for Engineering Education Annual Meeting, Purdue University, Lafayette, Indiana.

June 27-29—Canadian Electrical Association Annual Convention, Murray Bay, Quebec.

May 25-27—National Specialists Meeting on Guidance of Aerospace Vehicles (Institute of the Aeronautical Sciences) Boston.

Removal of Members of The Institute with No Addresses

The following members' mail has been returned to headquarters. As a result, their names have been removed from the Institute membership list, but would be readily reinstated if a current address were forthcoming. Information regarding them should be sent to: Records Department, The Engineering Institute of Canada, 2050 Mansfield Street, Montreal.

Members

Abel, William Henry, New Westminster, B.C.; Aitken, John Alexander, Estevan, Sask.; Beck, Etienne, Montreal, Que.; Bourgeois, R. P., St. Vincent de Paul, Que.; Bury, James Seeley, Port of Spain, Trinidad, W.I.; Chamberlain, J. A., Cambridge, Mass., U.S.A.; Chavignaud, Louis Georges, Edmonton, Alta.; Delisle, Maurice R., Montreal, Que.; Fleischmann, Albert Chas., Iberville, P.Q.; Forster, Arthur John, Vancouver, B.C.; Heaton, Eric Edward, Cornwallis, N.S.; Herring, Dennis P., Belleville, Ont.; Kent, Michael Robert, Ottawa, Ont.; Miller, Lawrence Fred, Sarnia, Ont.; Overland, Alf Gudbrand, Niagara Falls, Ont.; Pike, Robert William, St. John's, Nfld.

Juniors

Ballard, Allan, Ottawa, Ont.; Barr, Russell, Toronto, Ont.; Batistatos, C., Montreal, Que.; Bennett, Clive, Smooth Rock Falls, Ont.; Bishop, Wm. Campbell, Gravesend, Kent, England; Burks, Wilbert Gordon, Willowdale, Ont.; Butterworth, Robert R., Montreal, Que.; Candlish, James Ralph, Peterborough, Ont.; Cauchon, Camille, Quebec, Que.; Chan, Benedict, Fort Lee, N.J., U.S.A.; Chang, Ching-Ju, Montreal, Que.; Chapman, Fred. Wm., Kingston, Ont.; Colbourne, J. G., Fort William, Ont.; Cran, James K., Montreal, Que.; Curran, Gerald R., Dartmouth, N.S.; Dancose, Mark, Montreal, Que.; DeYoung, Roy Francis, Ottawa, Ont.; Fainbloom, Saul J., Montreal, Que.; Farrell, Reginald L., Hamilton, Ont.; Flook, John Cummer, Ottawa, Ont.; Floreani, Douglas B., Montreal, Que.; Fougere, Simon A., Quebec, Que.; Fownes, G. R. C., Leaside, Ont.; Gagnon, G. J., Montreal, Que.; Gilland, B. F., Winnipeg, Man.; Grant, Chas. H., Calgary, Alta.; Greenberg, Sam, Montreal, Que.; Hanks, N. A. R., Vancouver, B.C.; Haywood, Richard W., Vancouver, B.C.; Hornstein, Herbert, Montreal, Que.; Iwach, Eugene, Toronto, Ont.; Jamison, James Kent, Montreal, Que.; Jezzi, Boris, Estevan, Sask.; Johnson, Charles, Montreal, Que.; Jones, Edward S., Toronto, Ont.; Klein, Ernest Joseph Paul, Ottawa, Ont.; Knight, Oliver Walter, Ottawa, Ont.; Lafontaine, Denis, Montreal, Que.; Laporte, Raymond, Montreal, Que.; Lee, George Kwong, Kingston, Ont.; Leung, Paul, Montreal, Que.; Lowe, Donald Ulric, Kingston, Ont.; MacAulay, Colin Alexander, Elliott Lake, Ont.; Marsden, David John, Ottawa, Ont.; Mather, H. M., Vancouver, B.C.; McInroy, Andrew John, Ste. Genevieve, Que.; Merritt, Rex Dawson Vance, Toronto, Ont.; Morin, Paul H., Quebec, Que.; O'Doherty, Vincent James, Hamilton, Ont.; O'Sullivan, Dermot, Hamilton, Ont.; Papenhuyzen, Constant L., Peterborough, Ont.; Paquette, Gilles, Baie Comeau, Que.; Sauriol, Paul-Aime, Laval Des Rapides, Que.; Schleier, Henry John, Montreal, Que.; Skinner, George A., Vancouver, B.C.; Sled, John J., Vancouver, B.C.; Stevenson, Harold David, Vancouver, B.C.; Stewart, Vernon, G., Toronto, Ont.; Sus, Adam, Kitimat, B.C.; Tiberghien, Charles Jr., Galleywood End., Essex, Eng.; Turpin, John Francis, Montreal, Que.; Vallance, C. C., Saskatoon, Sask.; Vryenhoek, Ralph Douglas, Winnipeg, Man.; Waddell, Donald Edward, Ottawa, Ont.; Walsh, James Arthur, Streetsville, Ont.; Wilson, James, Hamil-

(*Continued on page 154*)

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News of the Branches

Dr. C. S. Landon, M.E.I.C., Commissioner of the Greater Winnipeg Sanitary District and the Greater Winnipeg Water District, has recently retired as secretary-treasurer of the Winnipeg Branch of the Institute after ten years of service.

Dr. C. S. Landon, M.E.I.C.

A native of Wellington, Prince Edward County, Ontario, Dr. Landon graduated with a Bachelor of Civil Engineering degree from the University of Manitoba in 1911 and obtained his Master of Civil Engineering from the same institution in 1914. His association with the Greater Winnipeg Water District began in 1916, when he accepted a position as special engineering assistant to the chief engineer. After serving with the 12th Battalion Canadian Railway Troop of the Canadian Expeditionary Force in the First World War, Dr. Landon became engaged in location and construction work in the provincial government highways branch of the Department of Public Works until 1931. From 1932-37 he served as representative for Manitoba in the Department of Labour, Ottawa and, from 1938-50, as regional construction officer for the Unemployment Insurance Commission.

His professional associations have been numerous, as member of the Dominion Council of Professional Engineers in 1940, 1942, and 1947; as member of the board of directors of the Canadian Good Roads Association, registrar and member of Council of the Association of Professional Engineers of the Province of Manitoba since 1934, and as secretary of the Winnipeg Branch for a decade.

Dr. Landon was a member of the University Council of the University of Manitoba, representing the graduates of engineering, for one term. He was also the first president of the University of Manitoba Students Union. He is a past honorary president and past president of the Engineering Alumni Association and a past vice-president of the University of Manitoba Alumni Association.

University of British Columbia

Bud Meckling, S.E.I.C.,
Correspondent

The new members of the branch were welcomed into office on April 1. They are: chairman, Don Nicholson; vice-chairman, Ed Schroeder; secretary-treasurer, Earl Stanley; public relations officer, Ron Barker; and field trip chairman, Victor Maydell.

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

As a preface to an analysis of the many factors affecting the safety of aircraft during flight, take-off and landing, Mr. G. T. McLean, test pilot for Canadair Limited, Montreal, made a general observation that all air accidents are due to human errors of one kind or another.

Mr. McLean, speaking at the March 24 meeting, made a detailed assessment of the take-off and landing characteristics of modern jet airliners compared to conventional airplanes. The operating limits imposed by length of runway and atmospheric conditions, and the relatively tight margin of safety under which the jet airliner operates, were among topics discussed.

Two short films were shown following Mr. McLean's talk, one on Canadair's new and original design of jet trainer, the CL-41; the other on the F-104, the supersonic interceptor built by Canadair to re-equip the fighter component of the RCAF.

Border Cities

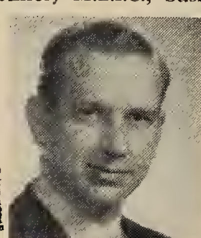
Report submitted by
V. Corin, JR.E.I.C.

On March 16, a joint dinner meeting of the Association of Professional Engineers of Ontario and the Institute was held in the Windsor area. Seventy-five persons attended.

Mr. Dwight Simmons, A.P.E.O. president, discussed the proposed formation

New Chairmen: (left to right) A. H. Austin, M.E.I.C., Kitchener; J. M. Reid, M.E.I.C., Border Cities; G. M. Woods, M.E.I.C., Brockville; N. A. Paolini, M.E.I.C., Sault Ste. Marie; L. T. Holmes, M.E.I.C., Saskatchewan; L. S. Piper, M.E.I.C., Kootenay.



of area groups similar to those of E.I.C. He also discussed the importance of updating and amending the Professional Engineers Act.

Calgary

Herbert Bailey, M.E.I.C.,
Correspondent

President Hanna and Mr. Garnet T. Page, E.I.C. general secretary, brought greetings from Institute Headquarters to the Presidential Dinner and Dance, March 18. Mr. Hanna urged all engineers to take a part in civic and community affairs. Mr. Page stated that the Calgary Branch had contributed significantly to E.I.C. and, in this regard, mentioned the Banff Regional Meeting in October and the recent A.S.M.E and C.C.A. conventions in Calgary.

Head table guests included: Mr. and Mrs. Allan Short, Mr. and Mrs. Bert Howard, Mr. Stewart Bartwell (Winnipeg), Mr. and Mrs. J. J. Hanna, Mr. Garnet Page, Commodore Cecil Davey, Mr. and Mrs. D. C. Jones, Mr. Tom Stanley, and Mr. and Mrs. J. S. Neil.

Chalk River

Report submitted by
C. E. L. Hunt, JR.E.I.C.

Mr. J. L. Galloway, of the Central Analysis Office of the Meteorological Service of Canada, gave a talk entitled "From Surface to Satellite or The Air Above Us" at the March 18 meeting. Beginning with a review of the history of meteorology, Mr. Galloway discussed some of the present theories on observed phenomena and recent information which has made these theories unsatisfactory. He explained the nature of the jet stream and outlined the high-altitude research being done at present in Canada and the U.S.

Fredericton

John M. Burrows, JR.E.I.C.,
Correspondent

"Transportation Demand from a Civil Engineer's Point of View" was the title of a talk by Professor Albert M. Stevens, of the University of New Brunswick's civil engineering department, on March 21. This was the regular joint dinner meeting of E.I.C. and the Association of Professional Engineers of New Brunswick.

Current practice in forecasting transportation demands favours the use of a method which relates the demand to land use. Because of the probable useful relationship between land use and engineering design loads for public works, it was urged that more extensive land use planning be carried out and that the engineering profession develop better correlations between land use engineering requirements. The coming census year is an appropriate time to initiate such a plan, the speaker suggested.

Kitchener

Report submitted by
W. L. Bulmer, M.E.I.C.

The Branch played host to the Grand Valley Engineers Association at a joint dinner meeting in the Iroquois Hotel, Galt, on March 25. Some 80 members and friends enjoyed an address by Mr. John S. Foster, manager of the Douglas Point Project in Bruce County which is being constructed for the nuclear power plant division of Atomic Energy of Canada Ltd.

Mr. Foster outlined the problems involved in selecting the location; compared the estimated cost of power with that of existing coal-fired generating stations; and described the operation of the equipment there. The 200 Mw. station is scheduled to begin construction this Fall using a peak employment of 500-600 persons. Completion is set for 1964 when an estimated 130 employees will be required for its operation.

Kootenay

I. Waterlow, M.E.I.C.,
Correspondent

President Hanna and Mr. E. C. Luke from Headquarters made a visit to the Branch on March 7. The executive meeting in the afternoon was followed by a dinner for the membership.

Laval University

Achille Leblanc, S.E.I.C.,
Correspondent

A banquet was given March 31 by the E.I.C. on the occasion of the graduation at Laval University. Mr. John Finn, assistant superintendent of transmission equipment methods, Northern Electric Company, Montreal, spoke on the topic "The Engineer in Industry".

Previous March meetings included a film from the Shawinigan Water & Power Company on the Beaumont Construction, March 2; a talk on "What For Scientific and Technical Progress?" by Dr. A. Wittenberg, professor of mathematics; and an address by Mr. Piette on laws for engineers.

Montreal

JUNIOR SECTION

Georges M. Desjardins, S.E.I.C.,
Correspondent

At the Annual Meeting held on January 25, 1960, at Institute Headquarters, the following executive was elected: chairman, Robert Walker; vice-chairman, Bernard Lamarre; secretary-treasurer, John Walton; officer-ex officio, Jacques Dubuc.

Nippissing and Upper Ottawa

W. A. Adams, S.E.I.C.,
Correspondent

Three members of the branch were the speakers at the March 16 meeting. Mr. W. M. B. Workman spoke on "Semi-Automatic Ground Environment", discussing particularly the Bomarc defence installations in the North Bay Area. Mr. G. M. Goodreid spoke on "Electrical Heating of Homes" and Mr. A. M. Bruce discussed the relative advantages of tyrex eord and nylon cord tires under the humorous title "Your life is Hanging by a Thread". The dinner meeting was held at the Manor Hotel, North Bay, Ontario.

Ottawa

H. P. Ristow, JR.E.I.C.,
Correspondent

Canada can not afford not to investigate the waters throughout the northern two-thirds of the country, stated Mr. D. A. H. Charles, officer-in-charge on the CGS Baffin, working with Canadian Hydrographic Surveys, Ottawa. He pointed out that the increased importance of air travel in the North requires that a sea route be kept open to bring fuel and supplies to airport bases, and that this can only be done with increased information for safe navigation.

The speaker followed his talk with a showing of colour slides taken on last year's voyage of the CGS Baffin.

Peterborough

D. B. A. Chase, JR.E.I.C.,
Correspondent

Rapid transit is reversing the trend towards the use of automobiles instead of public transportation in large cities, W. H. Patterson, chief engineer on subway construction for the Toronto Transit Commission, told a meeting of the Peterborough Branch on March 22, at the Kawartha Golf and Country Club. Clean stations and frequent service are winning people back to public transportation, he stated.

When Toronto's Yonge Street subway went into operation in 1954, it was hoped to carry 20,000 people per hour initially and 40,000 ultimately. The maximum is already being reached in peak traffic hours.

Mr. Patterson said that the success of the Yonge Street subway led to the approval of a ten-year program of subway construction including the east-west subway. The first stage is scheduled for completion in 1963 and the whole project is expected to be finished by 1969.

Mr. Patterson was introduced by P. F. Peele, Councillor for Peterborough, and thanked by Past President Howard Powell. The speaker was presented with a Peterborough-made wrist watch as a token of appreciation.

Saguenay — Lake St. John

Maurice Lavallee, JR.E.I.C.,
Correspondent

Approximately 50 members and friends met at the Saguenay Inn in Arvida, February 23, to hear Mr. G. W. Fletcher speak on "Atomic Reactor Operating Problems at Chalk River". Mr. Fletcher is head of the reactor technology branch at Chalk River which deals with reactor problems and safeguards.

All equipment built to contain the heavy water moderator is specially designed and constructed under extremely rigid specifications. Detection systems for leaks and failures have been installed to protect the purity of the heavy water. Its purity, stated Mr. Fletcher, must be 99.75% minimum to maintain the chain reaction in reactors.

Saskatoon

W. A. Friebel, M.E.I.C.,
Correspondent

President J. J. Hanna, visiting the Saskatchewan Branch on February 25, pointed out that engineers are likely to have to answer some embarassing questions in the future about what happened to Canada's natural resources. Concern for Canada's resources being put back into Canadian growth should be that of the engineer as well as the economist and politician, he stated.

An honorary membership was awarded Mr. R. A. Spencer, former dean of engineering at the University of Saskatchewan and now a consulting engineer in Saskatoon. Mr. Spencer has been associated with the Institute since 1907.

Vancouver Island

W. Tivy, M.E.I.C.,
Correspondent

Skin diving on construction work at the Dew Line in the Arctic was the subject of a talk by Lt. Cmdr. B. F. Ackerman of the Operational Clearance Diving Unit, Royal Canadian Navy, on the Pacific Coast. He explained that although skin diving is common for removal of ice bergs from harbours with dynamite and for changing screws on small naval vessels, it is still not used widely for making ship repairs. A film was shown of the application of standard diving to salvaging of the ship Normandy in New York Harbour.

(*Continued on page 154*)

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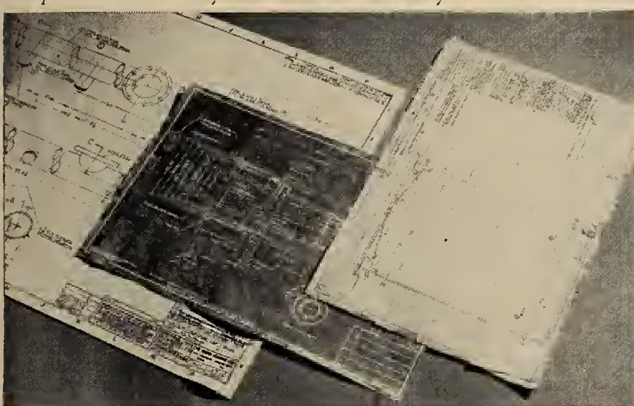

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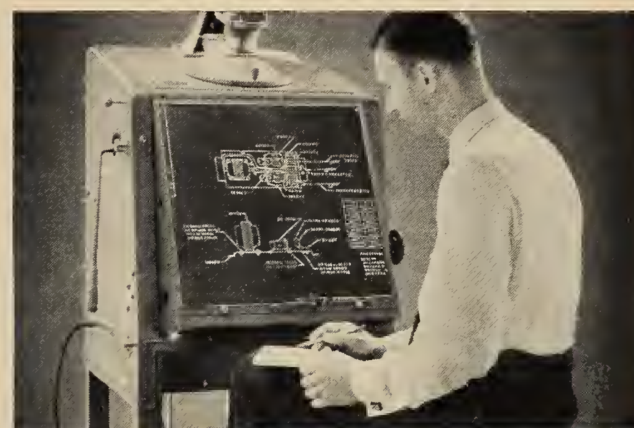

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Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*THEORY OF MACHINES THROUGH WORKED EXAMPLES, 3RD ED.

Worked out solutions are presented for about half of the 340 graded questions dealing with such aspects of machine design as kinematics (analysis of motion in linkages, gears, and cams), friction clutches, belts and brakes, inertia forces, and vibrations. A group of miscellaneous problems are grouped together in a chapter entitled "General Dynamic Problems." Brief reviews of principles, formulae, and methods of solution precede each chapter. (G. H. Ryder. London, Cleaver-Hume, 1959. 280 p., 21/–.)

*AMERICAN POWER CONFERENCE, PROCEEDINGS, 1959.

.These papers give practical information of broad overall interest to those concerned with the generation, transmission or utilization of power. The book is divided into sections dealing with topics of general interest; nuclear energy; electrical, mechanical, and water technology. The papers in each of these areas cover technical, economic, and industrial aspects. They are written by people connected with universities and societies, industries and government, laboratories and utilities. (Chicago, Illinois Institute of Technology, Technology Center. 776 p., $8.00.)

*AIRCRAFT ELECTRICAL ENGINEERING.

A survey of the varied techniques used in aircraft electrical engineering. Special attention is given to the presentation of environmental characteristics and the problems of high altitude brush wear, as well as to the cooling of electrical machinery in high speed aircraft. The aspects covered include vibration problems, direct current and alternating current machinery, switchgear, aircraft batteries and their behaviour on constant potential charge, electrical power systems, electrical installation engineering, and system operation and installation. (G. G. Wakefield. Toronto, Ryerson, 1959. 349p., $9.00.)

MODERN FISHING GEAR OF THE WORLD.

Edited versions of over one hundred papers presented at the first International Fishing Gear Congress, held in Hamburg in 1957. The papers, by experts from many countries, cover the following topics: materials used for fishing twines, and their characteristics, with particular emphasis on synthetics; net making and preservation; net design and efficiency; use of measuring instruments and underwater observations; fishing gear and its operation, different types of trawl, seines, etc.; the location and detection of fish; the attraction of fish; electric fishing. (Ed. by Hilmar Kristjonsson, F.A.O. London, Fishing News, 1959. 607p., £5.5.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 A.M. to 5 P.M.; All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

ANTI-CORROSION MANUAL, 1959.

In this second edition, a new section has been added on corrosion in industry, covering food manufacture, nuclear power, and petroleum refining. The whole volume has been revised, and several new sections added, including ones on cathodic protection, pipe coatings and tapes, and dehumidification. Chapters have been added on asbestos, clad steel, glass, degreasing, derusting and descaling, aluminum paints, zinc-rich paints, etc. Also included are details of relevant British Standard Specifications, and of British patents issued during the previous year. (London, Corrosion Prevention and Control, 1959. 326p., £3.)

INSTITUT INTERNATIONAL DU FROID, 1958.

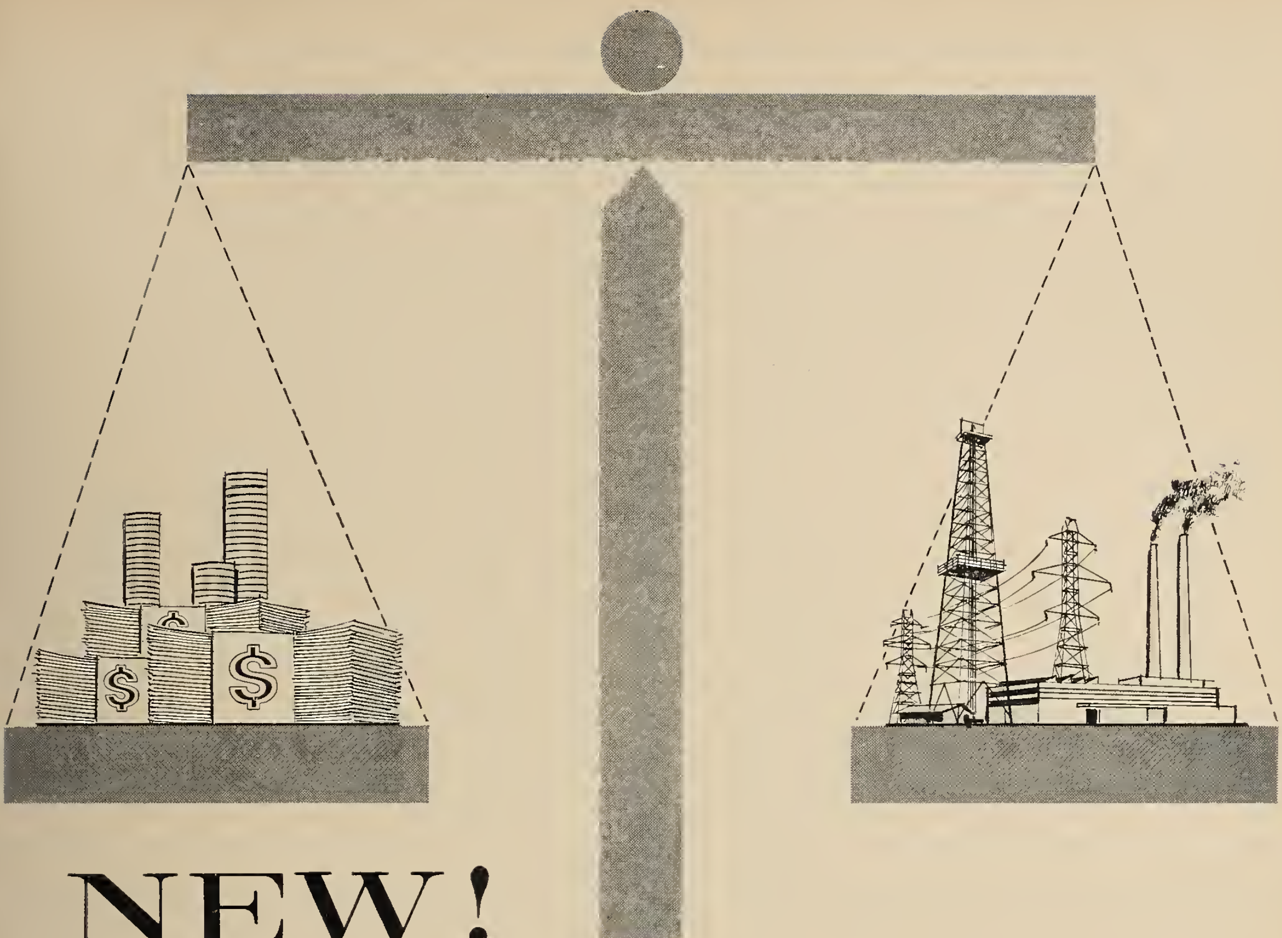
Over four hundred delegates from twenty-two countries attended the 1958 Moscow Conference of the International Institute of Refrigeration. The papers cover five topics: the quick-freezing of foodstuffs; automatic control in refrigerating machines and installations; heat exchangers; electrodynamic compressors; use of antibiotics in connection with refrigeration; the construction, equipment and operation of cold storage warehouses.

The papers are given in either French or English, with a summary in the other language. (Paris, Dunod, 1959. 747p., 6,000 fr.)

CALCUL DES PRIX DE REVIENT ET DES PRIX PREVISIONNELS DANS L'ENTREPRISE DE BATIMENT ET DE TRAVAUX PUBLICS, 2. ED.

This second revised edition is intended for those engaged in estimating construction costs, and tendering on civil engineering works. The author, who has had considerable experience in this field, analyzes the studies which have already been made on the subject, and presents a detailed review of the methods he has used himself.

Some of the topics covered are: organization of a construction company; construction costs; cost of machinery, amortization; price studies. There is a useful bibliography listing books in both French and English. (R. Tofani. Paris, Editions du Moniteur et des Travaux Publics, 1959. 406p., 2,300 fr.)



*MICROWAVE DATA TABLES.

The 26 tables included evaluate basic relationships of frequency, guide and free-space wavelength, standing-wave ration, voltage and power reflection coefficient, and the decibel. It is intended for wave guide engineers and for those concerned with high-frequency transmission lines of the coaxial and similar types. Guide wave-length tables are given for 9 sizes of rectangular waveguide and 2 sizes of circular waveguide. V.s.w.r. and frequency are given to 3 decimal places, and decibels to 2 decimal places; the dependent variable is usually given to four-figure accuracy. (A. E. Booth. Toronto, British Book Service, 1959. 61p., $6.50.)

ANALYSIS OF PIPE STRUCTURES FOR FLEXIBILITY.

The use of high-pressure and high-temperature piping systems has greatly increased the importance of analysis of pipe structures for stress and flexibility. This volume is intended for the piping designer, and covers codes and standards, both British and U.S.; stress calculation, using the elastic centre method; translation of the results of calculations; pipe supports; worked examples of complete analysis for single-plane and three-plane piping systems. (John Gascoyne. London, Pitman, 1959. 181p., 45/–.)

ENERGY PRINCIPLES IN APPLIED STATICS.

The two basic approaches to the analysis of statical systems are considered in this volume, which is confined almost solely to plane pin-jointed systems. The topics covered are: the use of the strain-energy and potential-energy methods of calculating the equilibrium of conservative statical systems; the principle of virtual work; the method of complementary energy; properties of systems with linear characteristics. There is a useful bibliography. (T. M. Charlton. London, Blackie, 1959. 112p., 25/–.)

PRINCIPLES AND USE OF SURVEYING INSTRUMENTS, 2ND. ED.

Intended primarily for students, this text deals with the principles and uses of all types of surveying instruments, while a companion volume covers the principles and practices of surveying. In this second edition, descriptions have been included, of self-aligning levels, wedge telemeters and split-image tacheometers, and of electronic methods of measuring distances. (J. Clendinning. London, Blackie, 1959. 205p., 25/–.)

PROBLEMS IN STRENGTH OF MATERIALS.

The problems in this volume are taken from the examination papers of London University, and of the Institution of Mechanical Engineers. There are 108 problems presented with fully worked solutions, in which emphasis has been laid on graphical or semi-graphical methods of solution, and 260 unworked problems for which answers are provided. The problems are divided into seventeen chapters, each covering a different aspect of the strength of materials. (R. S. Paradise and G. A. Church. London, Blackie, 1959. 278p., 25/–.)

THE TECHNICAL WRITER.

Sub-titled "An aid to the presentation and production of technical literature", it is the purpose of this volume to give the technical writer some idea of the processes through which a manuscript passes before it reaches its final printed form, as well as laying down the principles on which good writing is based.

In their first four chapters, the authors cover the different types of technical literature, the writing techniques used, styles and presentation, and types of illustration. Production problems are next considered, including printing processes, setting out the text, typography, and editing. Two final chapters discuss the organization of a technical publications unit, and problems connected with writing a book. There is a useful bibliography. (J. W. Godfrey and G. Parr. Toronto, Ryerson, 1959. 340p., $9.00.)

THEORETICAL ELASTICITY AND PLASTICITY FOR ENGINEERS.

An introductory account of the theory of elasticity and plasticity, intended for both students and research workers. The topics covered include: an analysis of stress and strain, and the invariants involved; the fundamental problems of bending, torsion and shear of a straight beam; two-dimensional analysis; problems in curvilinear coordinates; loads; theory of thin flat plates; the theory of plasticity for perfectly plastic bodies. Problems, with solutions, are included in each chapter. (D. E. R. Godfrey. Toronto, Longmans, Green, 1959. 311p., $8.40.)

*RANDOM VIBRATION.

The recent development of high power rocket and jet engines has introduced new aspects to the problem of mechanical vibration, since these units generate noise and vibrational energy in a stochastic manner over a wide band of frequencies. The twelve papers included are concerned with this problem and assume that the reader is already familiar with the classical problem of mechanical vibration. The first part of the book deals with the new concepts required to extend ordinary vibration theory into the field of random vibration, while the last part gives a broad picture of the current state of the art of designing and testing equipment which must withstand random vibration. (Ed. by S. H. Crandall. New York, Wiley, 1959. Various pagings, $8.50.)

HIGHWAYS OVER BROAD WATERS.

Growing up in the shadow of the Brooklyn Bridge, David B. Steinman was later to build more than four hundred bridges himself, on five continents. This biography traces the story of his interest in bridges, and his connection with them from his childhood to the completion of his greatest bridge at Mackinac. The author describes the work of designing and erecting many of Dr. Steinman's bridges, and also his activities in various fields of engineering—the founding of the School of Engineering of the City College of New York, the fight to obtain recognition for the engineering profession in New York State, the study of aerodynamic oscillations, etc.

Dr. Steinman has been the recipient of many honours and awards, including the Gzowski Medal of The Engineering Institute of Canada, of which he is a Life Member. (William Ratigan. Grand Rapids, Eerdmans, 1959. 359p., $6.00.)

IGY: YEAR OF DISCOVERY.

The author, the Chairman of the IGY steering committee, here gives a popular account of the work of scientists from 67 countries during the IGY, in the fields of study, the earth and the sun. He touches on the research carried out on earthquake waves, glaciology, oceanography, the atmosphere and upper atmosphere, the ionosphere, the sun, cosmic rays and nuclear radiation. He closes with chapters on the growth of natural science and national and international scientific organizations, and on the organization of the IGY itself. (Sydney Chapman. Toronto, Ambassador, 1959. 111p., $6.95.)

DICTIONARY OF AERONAUTICAL ENGINEERING.

An illustrated dictionary, compiled in the United Kingdom, covering all fields of aeronautical engineering, including terms used in connection with guided missiles, artificial satellites, jet propulsion, rockets, V.T.O.L. aircraft, helicopters, etc. The definitions given are concise, there are many cross-references, and explanations of the multitude of initials and abbreviations now in use are included. (J. L. Nayler. New York, Philosophical, 1959. 318p., $10.00.)

*ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING.

An extensive work that defines terms and provides descriptions and diagrams of equipment, components, and systems employed in electronics and nuclear engineering. Additional definitions are provided for terms in such closely related fields as electricity, physics, chemistry, and acoustics, particularly where they have a bearing on electronic and nuclear applications. Extensive cross-referencing is provided so that related entries may be studied and compared. (R. I. Sarbacher. Englewood Cliffs, Prentice-Hall, 1959. 1417p., $35.00.)

*AN INTRODUCTION TO ADVANCED DYNAMICS.

An intermediate text covering the concepts of classical mechanics, which is intended to prepare the reader for the modern ideas of quantum mechanics. The author discusses the fundamentals of Newtonian dynamics, Hamilton's principle and Lagrange's equations, central force motion, dynamics of a rigid body, oscillatory motion, Hamilton's equations and phase space, and the Hamilton-Jacobi equation. Emphasis has been placed on basic principles rather than on an exhaustive treatment. (S. W. McCuskey. Reading, Addison-Wesley, 1959. 263p., $8.75.)

QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES.

Many of the topics covered in this text are not discussed in detail in standard works on spectroscopy, although much of the background material is found in texts on astrophysics. The book is intended for students concerned with radiation and other problems connected with missiles and other modern propulsion devices. The subjects covered include thermal radiation; Einstein coefficients; spectral lines; absolute intensities of gases; absolute and relative intensities for atomic and molecular spectral lines; infrared vibration-rotation spectra and bands; infrared gas emissivities; emissivity of heated air; determination of flame temperatures; the effect of radiation on burning rate of solid propellants; radiant-heat transfer for propellants in liquid-fuel rocket motors.

Much of the work is based on research performed by the author's group. There are references at the end of each chapter. (S. S. Penner. Reading, Addison-Wesley, 1959. 587p., $15.00.)

*HYPERSTATIC STRUCTURES, VOLUME 1.

The field of hyperstatic structures is treated as a coherent pattern by means of a diagrammatic "family tree" which emphasizes the relationships existing among various theorems. Sections included deal with the energy theorems of structural analysis, general theorems for linear elastic structures, general methods for linear hyperstatic structures, moving loads on structures, frames with rigid joints, arches, stability of struts and frameworks, and matrix methods. (J. A. L. Matheson. Toronto, Butterworth, 1959. 474p., $15.50.)

*LIQUIDS AND LIQUID MIXTURES.

The equilibrium properties, and development of new methods for calculating the thermodynamic properties, of pure liquids, and the equilibrium properties of liquid mixtures, are discussed in the first two sections of this book. The final section is an account of the theories of liquids and mixtures, developing those parts of statistical thermodynamics common to all theories, and then restricting the account to results than can be compared directly with experiment. (J. S. Rowlinson. Toronto, Butterworth, 1959. 360p., $12.50).

A HISTORY OF WESTERN TECHNOLOGY.

Translated from the German, this is a history of technology in the form of extracts from contemporary writings, from the time of the Greeks to the present. The author has tried to show through these writings the influences which have guided technical progress in each era, and how the intellectual forces of each period affected, and were themselves modified by technology. The writings are from the works of many authors, including not only technicians but philosophers, scientists, economists and poets. The book is well illustrated by contemporary pictures and drawings. (Friedrich Klemm. Toronto, Nelson, 1959. 401p., $7.00.)

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NUCLEAR POWER PLANTS, PART 2.

Volume 9 of the Proceedings of the Second U.N. International Conference on the Peaceful Uses of Atomic Energy, this volume deals mainly with concepts of future power plants, and with conclusions drawn from experimental power reactors.

The papers from Session B-9 cover various types of power reactor; water, boiling water, organic cooled, gas cooled, liquid metal cooled, and homogeneous reactors. Session B-10 was concerned with power reactor experiments in the different types of reactor, and Session B-11 with experiences with the reactors. (Geneva, United Nations, 1958. 538p., $17.50.)

REACTOR PHYSICS AND ECONOMICS.

Volume 13 in the Peaceful Uses of Atomic Energy series contains the papers presented at Sessions B-19, B-15, and B-14b. B-19 heard eighteen papers on reactor physics and shielding. The twenty-three papers heard at Session B-15 discussed fuel cycles in various types of reactor, and the fuels used. Session B-14 was concerned with the economics of nuclear power, and the papers cover such topics as long-run trends in conventional and nuclear power costs; economic operation of nuclear reactors; combined use of nuclear and hydro-power; nuclear and pumped storage power schemes; Canadian economics related to nuclear power. (Geneva, United Nations, 1958. 635p., $18.50.)

*FRACTURE.

The papers presented at an international conference on the cleavage, ductile, fatigue and high-temperature atomic mechanisms of fracture of metals, ceramics and polymers, held at Swampscott, Massachusetts, in April 1959, form twenty-seven chapters of this book. Each chapter includes an abstract of its paper and intensive references, and most also include discussion of the content. A valuable feature of the book is the summary of the current status of experiment and theory and of the needs of future research, which forms the first chapter. (Ed. by B. L. Averbach, and others. New York, Wiley, 1959. 646p., $17.50.)

*ECONOMIC CONTROL OF INTERCONNECTED SYSTEMS.

Deals primarily with the treatment of mathematical methods, computers and controllers to obtain the optimum economic operation of interconnected electric utility systems, describing pioneer methods in operation applicable to all process industries. Included is discussion of important tools for the development of optimalizing computer controllers, such as theoretical and differential analyzer performance prediction methods, development of mathematical models of process, and use of advanced circuit methods. (L. K. Kirchmayer. New York, Wiley, 1959. 207p., $12.50.)

*COMPRESSION AND TRANSFER MOULDING OF PLASTICS.

A Plastics Institute monograph intended for students of mold design, designers, and mold shop executives. The section on compression molding gives historical background and development, discusses types such as cavity, three-plate, and split displacement molds, pretreating, molding with powders, and the effect of materials on mold design. Transfer molding is discussed in the same pattern, while covering also specific transfer problems as feed systems and size, gate areas and position, clamping pressures, and split dies. (J. Butler. Toronto, British Book Service, 1959. 230p., $8.00.)

*THE MAGNETO-IONIC THEORY AND ITS APPLICATIONS TO THE IONOSPHERE.

A detailed account is given of the theory concerned with the propagation of electro-magnetic waves through a partially ionized gas in the presence of a magnetic field. Two approaches are adopted in developing this theory: a macroscopic one in which the properties of the medium are averaged out, and a microscopic one based on the motion of the individual electrons. Graphical representation is then discussed and simple rules demonstrated for computing curves of refractive index and absorption index as functions of electron density. Applications of the theory to the earth's ionosphere is studied, and a wide range of phenomena capable of explanation in terms of the magneto-ionic theory of a homogeneous medium are indicated. (J. A. Ratcliffe. Toronto, Macmillan, 1959. 206p., $6.75.)

PRECIPITATION PROCESSES IN STEELS.

The report of a conference held at the University of Sheffield in 1958, this volume contains the twenty-one papers presented, together with the discussions which took place. The papers covered precipitation in ferritic steels, and in austenitic steels, intergranular fracture in steels, and precipitation during creep. There are many illustrations, and bibliographies are included in most papers. This is Special Report number 64 issued by the Iron and Steel Institute. (London, Iron and Steel Institute, 1959. 322p., £4.4.)

DICTIONARY OF ATOMIC TERMINOLOGY.

A selection of over 1800 terms used in connection with atomic and nuclear physics, reactor engineering, radiation physics and related fields, in four languages, English, German, French and Italian. The English terms are listed in alphabetical order and numbered, with the equivalents in the other languages in parallel columns. There are alphabetical indexes in the three foreign languages keyed to the English. (Lore Lettenmeyer. New York, Philosophical Library, 1959. 298p., $6.00.)

CURVE SURVEYING.

A handbook for road and railroad

(Continued on page 134)

• LIBRARY NOTES

(Continued from page 130)

surveyors interested in the design or re-alignment of circular and transition curves. The theory is given in full, but tables have been included to reduce the work of calculation. The first two chapters cover the setting out of circular curves with chain, tape and theodolite, and the location of compound and reverse curves. The amount of cant required on a transition curve is discussed, and the cubic parabola, the clothoid and the lemniscate are described. A final chapter covers the re-alignment of railroad curves by the Hallade method. (R. B. M. Jenkins. London, Cleaver-Hume, 1960. 184p., 35s.)

NATIONAL DIRECTORY OF THE CANADIAN PULP AND PAPER INDUSTRIES, 1959-1960.

In this edition the statistical information has been brought up to date, and the product index section under "Paper Products (Classified by Kinds)" completely revised. All the usual features of the Directory are included. Detailed information for the pulp and paper mills of Canada is arranged geographically by province; pulp, paper and board mills are classified by kind; there are lists of pulp and paper distributors, Canadian paper merchants, Canadian trade commissioners, organizations connected with the trade, and Ministries of Lands and Forests in Canada. (Ed. by J. N. Stephenson, Gardenvale, National Business, 1959. 530p., $5.00.)

DIGEST OF LITERATURE IN DIELECTRICS.

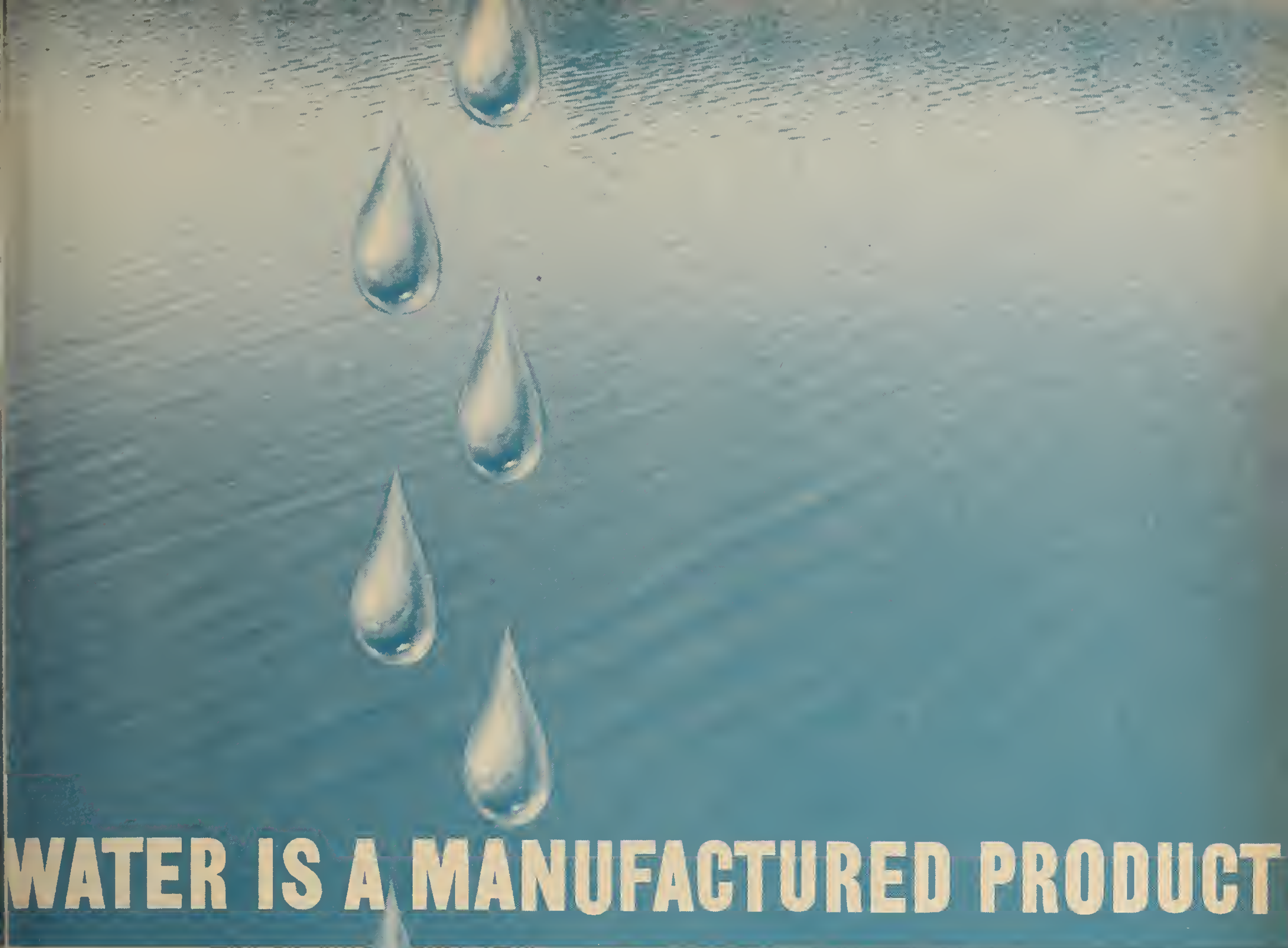
The twenty-second of a series of annual review volumes, this covers material dealing with the fundamental and applied aspects of dielectrics and dielectric phenomena published in the U.S. and other countries during 1958. There are twelve papers covering: instruments and measurements; dielectric constants; molecular and ionic interactions; conduction phenomena in solid dielectrics; breakdown of dielectrics; ferroelectric and piezoelectric materials; ferromagnetic materials; rubber, plastic and ceramic insulation; insulating films and liquids; engineering applications. Each review is accompanied by a bibliography of anything from 41 to 500 references. (Ed. by R. A. Soderman and L. J. Frisco. Washington, National Academy of Sciences-N.R.C., 1959. 293p., $5.00.)

*DATA BOOK FOR CIVIL ENGINEERS, VOLUME I: DESIGN, 3RD. ED.

A concentrated, tabular and illustrated collection of design data for civil engineering structures, with new material in this third edition in the sections on structural steel, concrete, wood, aluminum and masonry; wind pressures on structures; pavements, highways, airports, bridges and waterfront structures; and in drainage and sewage systems. All sections have been revised in accordance with the latest data, codes, standards, and practice. (E. E. Seelye. New York, Wiley, 1960. Various pagings, $24.00.)

*THE PETROLEUM HANDBOOK, 4TH ED.

This new edition of the handbook includes the changes in the industry through expansion of chemical interest and of research carried on in various parts of the world. It is a basic guide to the production, manufacture, storage, transportation, distribution, and application of petroleum products and chemicals. The manufacture of oil products covers distillation, cracking, absorption, reforming, and refining; applications include aviation, automotive, marine, industrial, and locomotive uses, petroleum wax, and bitumen. Petroleum chemicals fabrication and applications deal with solvents, detergents, synthetic resins and fibres, industrial and agricultural chemical derivations. (Comp. by members of the staff of companies of the Royal Dutch Shell Group. London, Shell International Petroleum Co. Ltd., 1959. 678p., No price given.)



*NUCLEAR POWER PLANT.

A review of the basic ideals underlying nuclear power generation for the informed reader. It opens with a concise account of world energy requirements and resources in the present and in the future. It goes on to deal with nuclear and reactor physics and reactions, types of reactor according to different means of classification, reactor engineering based on the unique reactor physics, the control of the heat output of the reactor, instrumentation, and economics of nuclear stations. The appendices contain comprehensive tables of elements, neutron interaction formulae, reactor theory, and a chronology of nuclear power development. (E. Openshaw Taylor. New York, Philosophical Library, 1959. 184p., $7.50.)

*HIGHWAY ENGINEERING, 2ND. ED.

The purpose of this book is to give an integrated picture of the whole field of highway engineering, presenting the material in the order in which it commonly would occur in the development of a highway or highway system. Administration, economics, financing, and planning are dealt with at length, followed by chapters on design, construction and maintenance, which stress fundamental principles. The new edition incorporates the major advances in the field, and shows the effect of the Federal Highway Act of 1956. (L. J. Ritter, Jr. and R. J. Paquette, New York, Ronald, 1960. 751p., $10.00.)

*MARINE CORROSION HANDBOOK.

Here is practical guidance, for non-specialists, on the prevention of corrosion in ocean-going ships, with the view toward application rather than scientific theory. Arranged alphabetically, the book gives rules of thumb for the choice of metals, the use of plastics for metal protection, and information on season cracking, stress corrosion, cathodic protection, anodic cleaning, corrosion fatigue mechanical descaling, and special pertinent qualities of each of the most commonly used metals. The author is Officer-in-Charge of the Dockyard Laboratory at H.M.C. Dockyard, Halifax. (T. H. Rogers. Toronto, McGraw-Hill, 1960. 297p., $12.00.)

*TANTALUM AND NIOBIUM.

This handbook on tantalum and niobium contains all available chemical and metallurgical information and provides text-indexed references to published words from the time of von Bolton (ca 1905). The sixth in a series of such publications dealing with the rarer metals, it gives full coverage to chemical processing, consolidation techniques, reactions with chemicals, gases and liquid metals, physical and mechanical properties, and production and applications of the metals, their alloys and important compounds. All information included has been analyzed by specialists. Comprehensive author and subject indexes are included. (G. L. Miller. Toronto, Butterworth, 1959. 767p., $21.00.)

STANDARDS RECEIVED

Canadian Underwriters Association standards. Canadian Underwriters Association, 410 St. Nicholas St., Montreal, Que.

CUA No. 10: 1959—Standards for the installation, maintenance and use of portable fire extinguishers.

CUA No. 31: 1959—Standards for the installation of oil burning equipment.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aviation. Space flight.
First into outer space, by T. J. Gordon and J. Scheer. N.Y., St. Martin's Press, 1959. $4.50.

Buyers guide.
The Engineer Buyers Guide, 1960. London, Engineer, 1960.

Chemical plants. Great Britain.
British chemical plants, 1959. London, British Chemical Plant Manufacturers Association, 1959.

Electric contacts.
1958 supplement to the bibliography and abstracts on electrical contacts. Phila., ASTM, 1959. STP No. 56-M. $2.50.

Engineering profession.
The engineering profession and unionization, by D. C. Greenwood. Wash., D.C., Public Affairs Press, 1960.

Fires and protection.
Function of new PCA fire research laboratory, by C. C. Carlson. Skokie, Ill., Portland Cement Association, Research and Development Laboratories, 1959. (Bulletin 109.)

International Science Foundation.
Proceedings of the International Science Foundation Brainpower Forum, 1958 Conference. Monterey, Calif., U.S. Naval Post-graduate School, 1959.

Ions. Analysis.
1959 supplement to the bibliography of spectrophotometric methods of analysis for inorganic ions, by M. G. Mellon and D. D. Bly. Phila., ASTM, 1959. STP No. 125-A. $1.75.

Materials testing. Fatigue.
1958 references on fatigue. Phila., ASTM, 1958. STP No. 9-J. $3.50.

Mines and mining. Quebec Prov.
Outline of progress of the mining industry in the province of Quebec during the year 1959, by E. E. Berube. Quebec, Dept. of Mines, 1960.

Nuclear energy.
Nuclear energy in Britain. Montreal, United Kingdom Information Service, 1959.
Nuclear power year book, 1960, ed. by W. C. Davidson. London, Rowse Muir Publications, 1960. £2. 12s. 6d.

Metallurgy.
Metallurgie, by R. Cazaud. 67th ed. 2 vols. Paris, Dunod, 1960. 6,80 new Fr. each.

Metrology.
Metrologie generale (grandeurs, unites et symboles) by M. Denis-Papin and J. Vallot. 4th ed. 2 vols. Paris, Dunod, 1960. 6,80 new Fr. each.

Radio oscillators.
How to use grid-dip oscillators, by R. P. Turner. N.Y., Rider, 1960. $2.90.

St. Lawrence seaway and power project.
Seaway bibliography; 14th supplement to edition of August 1, 1955. Massena, N.Y., St. Lawrence Seaway Development Corp., Office of Information, 1960.

Soil mechanics.
The mechanism of frost heaving in soils, by E. Penner. Ottawa, N.R.C., Div. of Bldg. Res., 1959. (Research paper No. 87) 50c.

Television circuits.
How to troubleshoot TV sync circuits, by I. Remer. N.Y., Rider, 1960. $2.90.

Windows.
Symposium on testing window assemblies. Phila., ASTM, 1959. STP No. 251. $2.25.

DRIVE TO HIT AT FAULTY VEHICLES

The car with the faulty brakes, lights, signals, steering, exhaust, wipers, horn, tires or mirrors is the target of a road safety campaign across Canada by the Canadian Highway Safety Council. The motto: "**Check Your Car, Check Your Truck, Prevent Accidents**".

• DISCUSSION

(Continued from page 85)

hence the maximum dependable energy output, according to conventional methods. To this dependable energy output he applies an assumed load factor and looks upon the resultant figure as the total power potential of the river system. He then applies a mathematical manipulation to distribute this total power potential over the existing power plants.

Such a procedure invites a few remarks. First of all, the step from maximum dependable energy to capacity potential is somewhat more complicated that the application of an assumed load factor. What is the load demand of the entire system? What is the make-up of the entire system? Are the hydro plants under consideration suitable for being placed in the peak of the load? The answer to such questions will determine the capacity potential, and subsequently we will find the resultant load factor of the hydro plants, rather than the other way around.

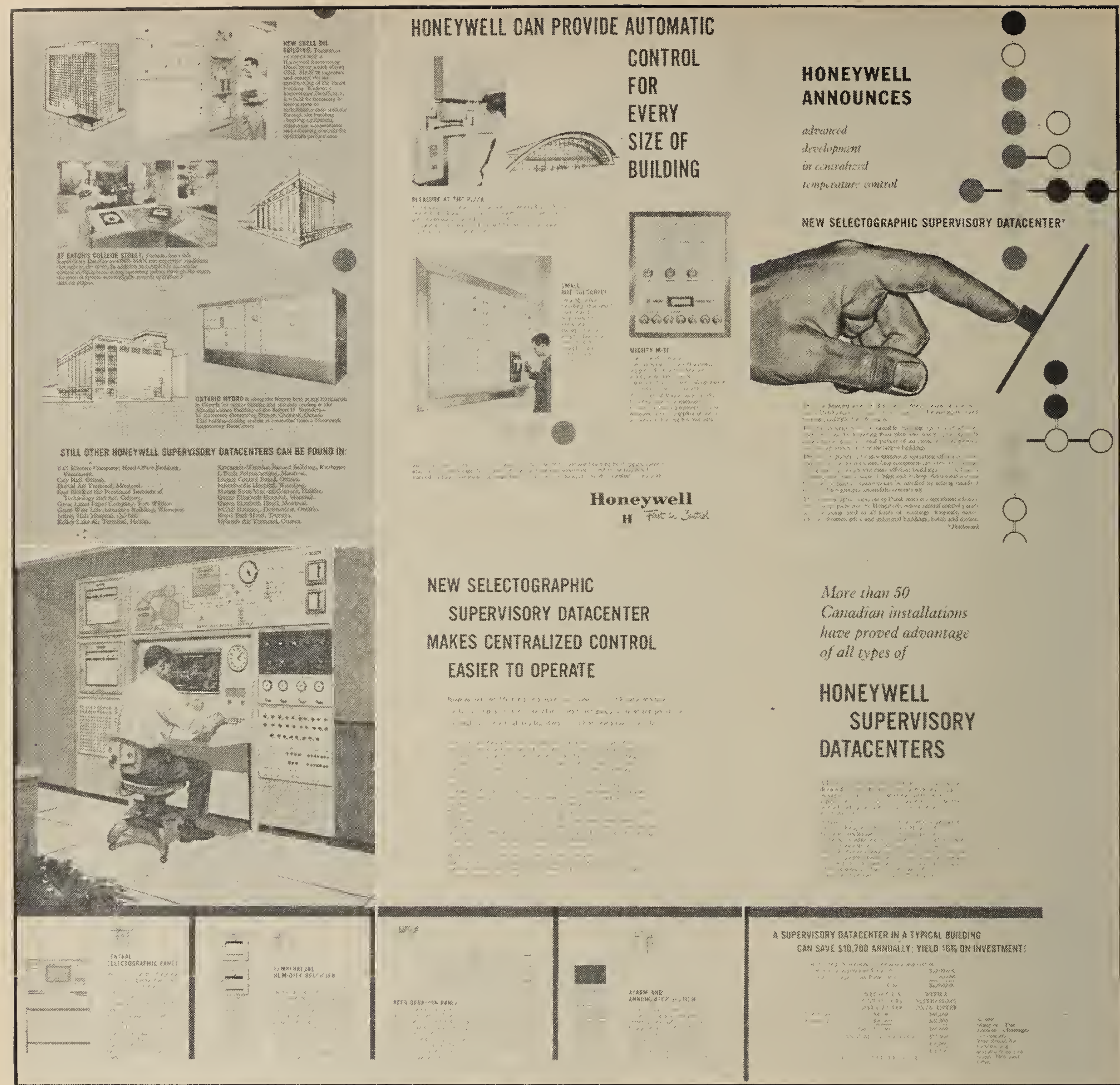
Secondly, even if we take the total power potential of the river system for granted, it would have limited value to distribute this total capacity over the individual plants with a manipulation that fails to take into consideration such governing factors as the incremental cost, pondage capacity, and hydraulic conditions of each individual plant.

Discussion by C. H. Atkinson

The paper presented by Mr. Cavadias gives a logical procedure for determining the energy output from a river system, and it is agreed that the computation of the total system output should give the optimum energy production. However, it is obvious that considerable trial and error guess-work must still remain in computing the regulation table. The reduction of inflow and discharge quantities in this table to energy units certainly simplifies the study, but the assumption of a constant kw.:c.f.s. ratio for each plant, which this involves, could not always be justified. This ratio is directly proportional to the overall plant efficiency and to the head. The former may be expected to remain within close limits under normal operating conditions, but the latter may vary widely, especially if the power plant utilizes the head from a reservoir which is drawn down during the winter. Under these conditions there would seem to be no alternative but to use tentative "Output vs Discharge" curves for the range of head which is envisioned at the reservoir. This in turn would make it necessary to carry out at least part of the regulation study in water-quantity units rather than in energy units, thus complicating the entire study and minimizing the use which could be made of punched-card computing machines.

The question of a variable kw.: c.f.s. ratio and more particularly of a variable head at the respective plants appears to have been purposely avoided by the author in this paper and it would be interesting to hear his comments on the inclusion of this factor in the study of energy potentials of rivers. This would be a step towards a more general case than that discussed in the present paper.

The regulation study is tedious



HONEYWELL CONTROLS LIMITED WINS CERTIFICATE OF ADVERTISING MERIT

Reproduced above, on a greatly reduced scale, is the four color, six page insert of Honeywell Controls Limited which was judged the "best" in the February issue from the viewpoints of ACCURACY-INFORMATION and ATTRACTION. The reproduction shows the front and reverse sides of the insert with the binding margin on the left of the top three pages and on the right of the lower three pages. The insert appeared as pages 109 to 114 of the issue.

E.I.C. CERTIFICATE OF ADVERTISING MERIT — WINNING ADVERTISEMENT

For the third time since the inception of the award of E.I.C. Certificates of Advertising Merit in January 1959, a Honeywell Controls advertisement has received the greatest number of votes by a fifty reader jury. The advertisement referred to appeared in the February 1960 issue. It is a six page, gate-fold, four color insert headed: "HONEYWELL ANNOUNCES advanced development in centralized temperature control NEW SELECTOGRAPHIC SUPERVISORY DATACENTER".

The advertisement has been carefully printed and designed and the copy is concise and factual. The jury which judged the advertisements was composed of "Journal" readers — five in each province. Each month different readers are asked to make their selection from the viewpoints of ACCURACY-INFORMATION and ATTRACTION.

K. K. Warne, Merchandising Manager of the Company, is in charge of the Advertising Department and the Toronto office of Cockfield, Brown & Co. Ltd. prepared and placed the advertisement.

work and if several alternative reservoir sites and capacities are possible the amount of work involved in computing a regulation study for each combination is very large. The author has clearly had considerable experience in this kind of study and it would be interesting to know if he has considered any methods, or manipulations, which may be used to extend the use of punched-card equipment to all phases of the regulation study.

In the last paragraph in section 3, the author mentions that the storages or groups of storages must equal the number of plants in the system before the method of determining the power production of individual plants can be applied. There would be no difficulty however in applying the method to a system where the number of storages is less than the number of plants. In Fig. 2 for example one reservoir feeds controlled flows to two plants, although, in this particular case it may be possible and preferable to group the two plants together if the uncontrolled flow entering the river between them is small compared with the total flow at plant P_2.

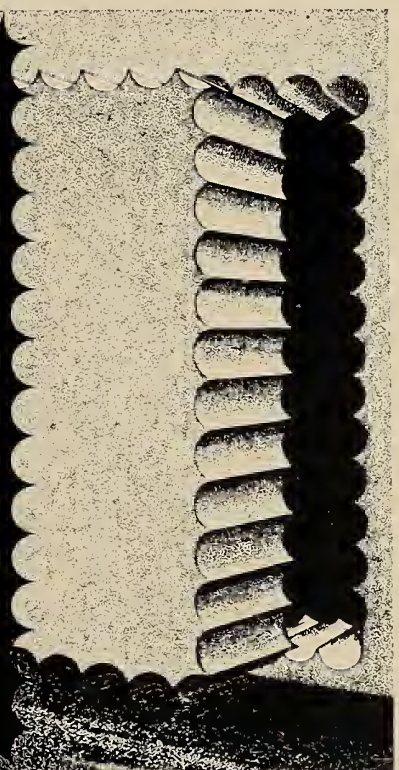
Discussion by G. H. Scruton, Jr.E.I.C.

The method outlined by Mr. Cavadias not only is useful in examining the potential of undeveloped rivers, but also in studying the effect of adding new plants to rivers which already are partly developed and of combining hydro-electric generation with other sources of energy supply. It provides a systematic means of studying the hydro-electric system as an integrated whole, rather than a series of individual plants.

In hydro systems, one of the great difficulties in determining primary and secondary energy estimates from flow-duration curves for individual plants located at some distance from each other on a stream which is regulated by the operation of storages, lies in the fact that the high flows occur at plants close to the storages during the periods of low run-off, while those at plants remote from the storages prevail during flood periods. Under these circumstances the total power approach is of considerable advantage and demonstrates the value of the interconnection of the plants.

For a planned addition to a system, an estimate of the benefit can be obtained by regulating the river for total power output, both with and without the planned addition, and the resulting total power duration curves examined. The difference in area between the two curves represents the increase in system energy production that can be credited to the new asset and the improvement in the curve at the right hand side is the increase in prime production. In one study, in which the method was applied, the increase in prime production equalled the increase in production, and in another, it exceeded the increase in production. In other words, some of the secondary presently generated by the existing plants was converted to prime just by the addition of a new plant. These were important conclusions that were obtained from the use of the total power approach.

In studying installations, the procedure can be followed of dividing the total primary power output by the system prime load factor in the same way that is sometimes followed in studies of individual plants. The difference between the results obtained from the two total curves is



the increase in peak that can be justified by the planned addition which then may be distributed amongst the planned and existing plants using the maximum production principle or, since it is unlikely that changes would be made to existing installations, it can be installed wholly at the proposed new plant or plants following the principle of minimizing the cost.

For interconnecting with other companies and/or with thermal plants, an adaptation of the method shown in the "Hydro-Steam Association" chapter of Doland's book "Hydro-Power Engineering" can be helpful for preliminary studies. The average annual energy contribution of the hydro system to the load is represented by the total power duration curve, and the difference between it and the demand curve is the amount of energy required from other sources. Use of this application to an interconnected system gives an indication of how much of the hydro generation is prime and how much is secondary.

The maximum production principle for selecting installations is an interesting aspect. It appears to give reasonable results for first approximations; however, one must also consider the ponding facilities of the individual plants and the proximity of the power plant to the storages to name just two other conditions. When the plant is near the storages, high flows have prime value and this fact must be considered.

In summary, the paper gives a method of studying a series of hydro plants on one river as a system and permits hydrologists and engineers to express mathematically the firming-up effect of the addition of new plants and other sources of energy to an existing system. It is this total power approach which makes the paper valuable.

Discussion by J. K. Sexton, M.E.I.C.

In his paper Mr. Cavadias derives a set of equations which express in simple form the basic conditions governing the operation of a system of hydro plants and reservoirs for maximum output of primary energy. In so doing he automatically emphasizes the point that while it is possible to compute storage operation in terms of water, or c.f.s., for the simple case of reservoirs supplying a single hydro plant or several hydro plants without significant intervening runoff, it is necessary to base the computations on energy or kwh. per hour for all other cases. Thus in the analysis of a complex hydro system the stream flow at each plant is expressed as the kwh. per hour it is capable of generating through the prime movers at the site, and the volume of live storage at each reservoir is expressed as the kwh. the impounded water can produce at the plants through which it will flow. This is the normal method used by hydro production men to control system operation to maximum advantage.

The computations for such hydro system operation are usually done by trial and error and may in some cases be tedious. Apparently Mr. Cavadias does not depart from this trial and error method in the application of his formulas. He does, however, refer to the use of punched card computing machines and postal card sorting machines in the concluding paragraph of his paper, and it would be interesting if he would enlarge upon this reference. In the writer's experience there are distinct limitations to the use of computers in power supply studies since it frequently happens that there is insufficient repetition of operations to justify the preparatory work involved.

Referring to the details of Mr. Cavadias' paper, it would be interesting to know the reason for the inclusion of columns 12 and 13 in table 1. There is no indication in the paper of the way in which they are used, unless it is that column 13 assists in the trial allocation of load to the plant by indicating the maximum possible.

Mr. Cavadias' method of determining optimum capacities for the various plants of a hydro system is an interesting piece of mathematical deduction, and no doubt that is the way in which it is offered. In actual cases, of course, capacities of individual hydro plants are affected by a number of conditions such as head, pondage, type of construction, distance from markets, characteristics of other plants or the system and interconnections with systems. Moreover, hydro plant capacities usually reflect the changing importance of these various factors as the system evolves. For example, in a number of Canadian systems there is a growing proportion of thermal capacity which requires a review of the capacities in existing hydro plants. In such cases it is usually profitable to add to the hydro capacity far beyond that which was economical before the portion of the energy derived from thermal sources became significant.

Reply to the discussions by the author

In connection with Mr. Sexton's question concerning the use of punched card equipment in Power potential studies, I would like to mention that the equipment used in one particular application was fairly standard and consisted of the following I.B.M. machines:

1) 077 Collator
2) 082 Sorter
3) 407 Printer
4) 602A Calculator
5) 519 Reproducer

In another case a commercial Recording and Statistical Service offered:

1) To punch and check 12,000 cards.
2) To print the corresponding tabulations.
3) To prepare duration tabulations of mean monthly flows for 50 rivers with 20 yr. of records


power on site
from the word GO!

each, for a total fee of $500.00.

The problem of determining the capacities of the plants of a hydro system is admittedly complicated. The relatively simple criterion suggested in the paper is useful in preparing a first estimate of plant capacities, which is a necessary basis for cost estimates. In further stages of the study, the remaining factors mentioned by Mr. Sexton should be taken into account.

Mr. Scruton offers an interesting remark on the usefulness of the proposed method in the case of hydro-steam interconnection. An adequate coverage of this aspect is given in a paper by L. S. Wing and R. H. Griffin, mentioned in Mr. Renger's discussion.

Mr. Atkinson's question concerning the case of variable $\frac{KW}{CFS}$ ratios is interesting. In one system studied by the writer, the $\frac{KW}{CFS}$ ratio used for one plant with variable head, was calculated from the total energy production and the total discharge of the plant during the entire period of record.

This procedure is not applicable when most plants of the system have variable heads. In this case the method described in the paper is not applicable, as Mr. Atkinson points out. This subject merits further investigation.

Considerable work has been done in the last few years on the possibility of extending the use of computing equipment to the main phase of the regulation study. An interesting paper on this question has been presented by J. D. Ellis.*

Mr. Atkinson's last question was caused by a typographical error in the preprint of the paper, which was corrected in the printed version.

In reply to Mr. Kuiper's remarks, I would like to point out that the study of a hydroelectric development is usually carried out in a series of successive approximations, from the first rough estimates to the final design. The methods used at each stage should correspond to the degree of accuracy, both of the data available and of the results required.

The study of load conditions usually precedes the study of plant capacities and therefore the load factor can be considered as known, as was done in the paper.

In connection with the method of distributing the total installation, it should be noted that in order to determine incremental costs, a starting installation figure is necessary and this is supplied by the simple criterion of the paper. This criterion does not apply in the case of peaking operations at one or more plants.

Mr. Thomas's remark concerning the load factor is justified. The load factor used in the paper is applied to the prime power. For studies of this type it is sometimes acceptable to disregard the benefit from the production of secondary energy in determining the total installation.

Mr. Thomas's comment on the determination of the individual installations is obviously due to a misunderstanding of the problem, which is a non-trivial maximization problem with constraints.

Mr. Renger's and Mr. Clinch's remarks on the range of application of the proposed method are justified and constitute a useful complement of the paper. This can also be said generally for most of the comments contained in the discussions of this paper.

*The optimum use of water for Power calculated by Datatron electronic computers; Proceedings 26th Annual meeting. Western Snow Conference, April 1958.

● BRANCH NEWS

(*Continued from page 122*)

Winnipeg

P. M. Abel, JR.E.I.C.,
Correspondent

Dr. D. M. Stephens, chairman and general manager of the Manitoba Hydro-Electric Board spoke on Manitoba's program for power development at the March 17 meeting. After reviewing the history of the hydro-electric development of the Winnipeg River, Dr. Stephens discussed the progress of the Manitoba Hydro-Electric Board which has just completed the Brandon steam plant, is currently constructing the Selkirk steam plant, and is also at work on the Kelsey Hydro plant on the Nelson River.

It was announced that Prof. H. A. McDiarmid of the University of Manitoba's electrical engineering department would succeed Mr. G. C. March as general papers chairman of the branch.

Prizes and medals were awarded to the following university students: E.I.C. Summer Thesis Prizes, Civil III, A. M. Lansdown, "Cement — A Brief Introduction to its Manufacture"; Electrical IV, M. C. Chesley, "Analysis of Sub-transmission and Primary and Secondary Distribution of Electrical Energy and a Study of the City of Winnipeg Hydro-Electric Distribution System". Students papers competition: first, Charles Lamont, Mechanical IV, "Asphalt Paving"; second, Dennis Johnson, Electric IV, "Air Traffic Control"; third, R. Bevis, Mechanical IV, "Petroleum Refining". Presentations were made by Professors Riddell and McMath, chairman of the civil and electrical departments respectively.

Student Section

Don Brown, S.E.I.C.,
Correspondent

Mr. J. J. Hanna, president of E.I.C., addressed a meeting on February 22 and presented a certificate of merit to Miss Wendy Woods who was chosen the outstanding student in third year during the 1958-59 term.

Student branch elections were held on March 24 and the new executive includes: chairman, Brian Grover; vice-chairman, Don Brown; secretary-treasurer, Avron Arenson; membership, Ken Biccum.

Yukon

Lt. J. P. MacGowan, M.E.I.C.,
Correspondent

The Annual Meeting of the Yukon Branch was held at the Whitehorse Inn March 24. The following persons were elected to the new executive: chairman, Lt. Col. J. H. Reeves; secretary, Lt. J. P. MacGowan; treasurer, Mr. G. W. Elkington.

The principal speaker was not able to be present; however, Mr. Grant Starr, the out-going chairman, gave an illustrated talk on the construction of the Banff-Jasper Highway.

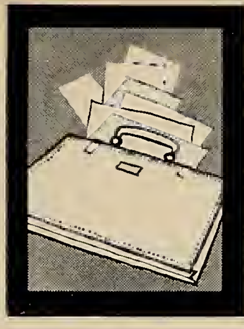
• REMOVAL OF MEMBERS OF THE INSTITUTE WITH NO ADDRESSES

(*Continued from page 108*)

ton, Ont.; Wilson, Ralph G., Redwood City, Calif., U.S.A.; Wright, Eric Manning, Montreal, Que.; Yunker, John Denis, Red Deer, Alta.

Students

Adjouri, Antoine, Montreal, Que.; Austford, Victor Mundi, Winnipeg, Man.; Bailey, Samuel M. B., Cornwall, Ont.; Barrett, Neil A., Halifax, N.S.; Beard, Wm. Morley, Uranium City, Sask.; Belanger, Andre, Ottawa, Ont.; Bennett, Paul Jerome, Ottawa, Ont.; Bertrand, Joseph Paul, Macamic, Abitibi, Que.; Billinton, Roy, Winnipeg, Man.; Blais, Gabriel, Montreal, Que.; Boulanger, John Albert, Saskatoon, Sask.; Bourgie, Paul, Ottawa, Ont.; Brennan, John Wm., Ottawa, Ont.; Brodeur, J. R. J., Shawinigan Falls, Que.; Brooks, Charles Donald, Toronto, Ont.; Brown, Peter Montgomery, Vancouver, B.C.; Bureau, Jacques, Montreal, Que.; Caletti, Dante Anthony, St. Lambert, Que.; Caron, Jean Michel, Ottawa, Ont.; Cartar, Theodore Fitzroy, Toronto, Ont.; Chorel, Marcel Joseph, Saskatoon, Sask.; Con, Ton That, Montreal, Que.; Cordeau, Francois, Halifax, N.S.; Csavinszky, Katalin, Ottawa, Ont.; Cutcliffe, Benjamin J., Fredericton, N.B.; Darke, Kenneth H., Toronto, Ont.; Davis, Wellesley Arthur, Fredericton, N.B.; Delisle, Gilles, Levis, Que.; Dent, Allan Gerald, Squamish, B.C.; Derome, E. J., Pointe Claire, Que.; Deskin, Eric, Montreal, Que.; Down, J. M., Colbert, Ottawa, Ont.; Drapeau, Jean-Paul, Montreal, Que.; Dufresne, Robert, Montreal, Que.; Faulkner, Peter Graeme, Peterborough, Ont.; Fernandez, Jorge, Ottawa, Ont.; Fortier, Florent, Montreal, Que.; Fraser, Norman, Gatineau, Que.; Friedrich, Charles Joseph, Duncan, B.C.; Gauthier, Clovis J. T., Charlevoix, Que.; Gauthier, Patrice, Ottawa, Ont.; Gauthier, Vincent, Hull, Que.; Gillies, G. R. (Mrs.), Montreal, Que.; Godin, Roger, Quebec, Que.; Grace, Philip Carl, Toronto, Ont.; Hay, Winston Cuthbert A., Toronto, Ont.; Hickson, Paul Justin, Toronto, Ont.; Huot, Jean Claude, Montreal, Que.; Isaacs, Albert Thomas, Vancouver, B.C.; Jaycock, Sidney, Davies, Windsor, Ont.; Joseph, Harrison Thomas, Halifax, N.S.; Kadlec, Robert Edward, Toronto, Ont.; Kalogerakis, E. E., Ottawa, Ont.; Keilani, Abdel Kader, Montreal, Que.; Kennedy, J. V. C., Ottawa, Ont.; Lacroix, Raymond, Ottawa, Ont.; Lapointe, Guy Francis, Brockville, Ont.; Lawson, Victor Bruce, Vancouver, B.C.; Lebel, Joseph Maurice, Three Rivers, Que.; Lechman, Edward Michael, St. Boniface, Man.; Lecompte, Jacques, Ottawa, Ont.; Leduc, Fernand, Montreal, Que.; Lepage, Jean Paul, Valleyfield, Que.; Leroux, Adrien, Sherbrooke, Que.; Leroux, Pierre G., Geneve, Suisse; Lindsay, Russell McLeod, Vancouver, B.C.; Logothetis, E. B.; Montreal, Que.; Long, Norman, Montreal, Que.; Lubelsky, Richard George, Montreal, Que.; MacInnis, Earl Vincent, Halifax, N.S.; MacKinnon, Earl Harry Arthur, Halifax, N.S.; Marquis, Paul Emile, Granby, Que.; Mattiuz, Edward John, Ottawa, Ont.; McHattie, James Grant, Saskatoon, Sask.; F/O McKinnon, A. J. K., Winnipeg, Man.; McLarty, James Gordon, Ridgetown, Ont.; McLeod, Roderick, Donald, Regina, Sask.; McMahon, Garry Moore, Saskatoon, Sask.; McNabb, Donald Glen, Burlington, Ont.; Menard, Kenneth, Montreal, Que.; Metaxas, Demetre, Montreal, Que.; Methoti, Bernard, Montreal, Que.; Minielly, Keith Alexander, Vancouver, B.C.; Mitchell, Delbert George, Saskatoon, Sask.; Muir, Stanley E., Montreal, Que.; Mulligan, Floyd Allan, Rosser, Man.; Nemet, Imre, Fredericton, N.B.; Nguyen, Van Duyen, Tetreautville, Que.; Parent, Robert, Ottawa, Ont.; Park, David Ernest, Mara, B.C.; Perreault, Gaetan, Sarnia, Ont.; Perry-Whittingham, A. J., Victoria, B.C.; Peterson, Frederick Lawrence, Winnipeg, Man.; Plourde, J. A. J., Montreal, Que.; Poirier, Rene, Montreal, Que.; Pratt, Merle Albert, Hartland, N.B.; Preston, John Michael, Montreal, Que.; Provencher, Roland, Ville Lemoyne, Que.; Pullman, Arthur George, Vancouver, B.C.; Rae, Ewing Alexander, Toronto, Ont.; Redfern, John Douglas, Kingston, Ont.; Rice, Douglas John, Lethbridge, Alta.; Rivard, Alexander Pierre, Tilbury, Ont.; Robertson, Alexander Readman, Dauphin, Man.; Romano, Alain Harwood, Montreal, Que.; Rosenberg, Stanley, Toronto, Ont.; Roy, Jacques, Montreal, Que.; Roy, Pierre Marc, Ottawa, Ont..; Rusk, Wm. Elgin, Vancouver, B.C.; St. Pierre, J. G. Normand, St. Eustache, Que.; Sewell, Carl Montague, Portneuf Village, Que.; Shelton, Victor George, Winnipeg, Man.; Simard, Jacques, Chambly Bassin, Que.; Singh, Virindar, Vancouver, B.C.; Smith, Leo Camille, Montreal, Que.; Stothers, James David, Saskatoon, Sask.; Timleck, Arthur James, Sherbrooke, Que.; Tong, Stephen, Ottawa, Ont.; Troyer, Cameron George, Winnipeg, Man.; Tyityan, Edward Steven, Toronto, Ont.; Verville, Claude, Montreal, Que.; Voduc, Dren, Montreal, Que.; Waddy, Roland, Harvey, Westview, B.C.; Walker, Edward Carl, Port Elgin, Ont.; Win, Maung Kyaw, Kingston, Ont.; Yoshida, Tsutomu, Regina, Sask.



Business and Industrial Briefs

Appointments and Transfers

Fred W. Argue, born in Parry Sound and educated in Sault Ste. Marie, has been elected president of Stone & Webster, it was reported recently by the Canadian affiliate, Stone & Webster Canada Limited.

Shawinigan Water and Power announces the election of **H. Greville Smith,** C.B.E., to the board of directors. Mr. Smith is chairman of the board of British Newfoundland Corporation Limited and a director of a number of other companies.

Ronald R. McNaughton, manager of the Metallurgical Division of Cominco at Trail has been elected president of the American Institute of Mining, Metallurgical and Petroleum Engineers (A.I.M.E.).

T. Gordon Willows is the new construction manager of Ontario Hydro's St. Lawrence Power Project at Cornwall. Mr. Willows has been associated with the St. Lawrence project as project engineer, special assistant to the Commission's chief engineer, Dr. Otto Holden and until this appointment, as Field Project Engineer.

Two plant managers in Dupont's chemicals department have switched jobs. **I. D. Vessie,** works manager at the finishes plant at Ajax, became manager, chemicals, at the Maitland Works near Brockville and was succeeded at the Ajax plant by the former manager at Maitland, **W. R. Anderson.**

Ross Engineering of Canada Ltd., announces the retirement of **F. William Hooper,** who has served as Vice President and General Manager of the company since 1935. He is succeeded by **Ralph R. Willis.**

Paul Doyon, B.A., B.Sc., formerly a development engineer at the head office of Canadian Liquid Air Company in Montreal, has been appointed branch development engineer of the Toronto Branch. A native of Sherbrooke, P.Q., he is a graduate of Montreal and Laval Universities and a member of the Canadian Welding Society.

Martin Berlyn has been appointed Manager of Engineering Services by Dominion Engineering. Prior to his present appointment he was Manager of Quality Control Services. Mr. Berlyn has been with Dominion Engineering since 1929.

The appointment is announced of a General Electric (U.S.) engineer to assist Canada in the licensed manufacture of G-E's J79 Turbojet engines for Canada's F-104 Starfighters. **Peter R. Tolley** has been named resident consultant and will be located at the Orenda plant in Toronto.

Business News

LEONARD H. DALE, Managing Director of Dale Electric (Yorkshire) Limited, England, is now touring Canada visiting agents and appointing new agents to handle his company's range of generating plants. The company is one of the largest producers of generating equipment in Great Britain.

WHEN TO APPRAISE is the title of a new brochure put out by Warnock Hersey to describe how valuation services may be profitably applied to many areas of economic activity.

CANADIAN BUILDING DIGEST is the name of a new series of publications now being issued each month by the Division of Building Research, National Research Council. Each issue presents a summary, generally of one topic, for the information of those who deal with the technical and related aspects of building.

SHAWINIGAN'S SPENDING may reach $225 million for the five years 1960-64, the company's president, J. A. Fuller, told shareholders at the annual meeting. Shawinigan expects to begin work on new power producing facilities next year and will have to raise additional funds from investors.

A HIGH SPRAY RATE and exceptional deposit efficiency are features of the new lightweight, compact, Spraywelder Unit now obtainable from Wall-Colmonoy (Canada) Limited. Spray rate is over 12 lb/hr. and the new equipment provides 20% reduction in spray pistol weight.

THE DEPENDABILITY NEEDED in a really lightweight motor-in-head one man vibrator is provided by a new electric Concrete Vibrator announced by Remington Arms of Canada. Known as a Model EV-26, the new tool operates on either AC or DC at the rate of 10,000 vibrations per minute.

COLOUR POSTCARDS are now used by the Walworth Company to illustrate products. Designed primarily for salesmen's use, the cards also have value as direct mail pieces sent to customers with no message other than the printed caption and a signature.

DRAWBACKS IN THE CONVENTIONAL bell and horn signalling method of communication in mines are overcome by the new Westinghouse Minecom System. Minecom is a transistorized radio and telephone system which can be used in a variety of ways. The hoistrope can be used as a transmission medium for either voice or coded audible signalling. It is battery operated from the conveyance and no cables are needed between the transmitter and receiver.

CAUSTIC POTASH is to be produced in Canada by C.I.L. in a new plant to be located on the site of the company's Cornwall works. Caustic potash is used in heavy duty soaps and detergents, liquid fertilizer, oil refining and a number of other industries.

A BUILT-IN BALLAST is a feature of the new Form 400 IB Mercury Street Lighting Luminaire announced by General Electric. The ballast compartment is serviced through the lift-top cover which enables all mounting, connecting and servicing to be done from on top of the luminaire. Installation is simplified and wiring time considerably reduced. The new luminaire is ideal for expressways, downtown business streets or any area where a high level of lighting is desired.

EMERGENCY OXYGEN UNITS that may be kept in readiness indefinitely without production deterioration are available from the Linde Company, a Division of Union Carbide.

INDUSTRIAL AND THERMAL products built by Montreal Locomotive Works will henceforth be marketed under a new name: MLW Industries Division. Announcing the change, William E. Lewis, executive vice president, pointed out that the company now serves not only the railroads but oil refining, chemical processing, power, steel, and pulp and paper, and produces a wide range of general industrial equipment.

WATER AND DAMPNESS are resisted by the closed cell structure of Insulair, a rigid plastic foam material now being produced by Dominion Rubber. The compound insulation and plaster base, eliminating the need for separate base and furring strips and permitting ready bonding to most wall surfaces, reduces material and labour costs.

HYDROSTATIC POWER TRANSMISSION, the newest practical development in transmissions for vehicles, will be shown in New York by Dowty Group Limited, Cheltenham, England, at the British Exhibition, June 10-26 in the New York Coliseum. This first efficient application of hydrostatic power for vehicle use is now incorporated into British road building vehicles, diesel locomotives, cranes and military vehicles, as well as being used in mining equipment, industrial drives and marine applications.

FERRANTI-PACKARD ELECTRIC has been granted exclusive rights to market in Canada the complete line of products of the Capacitor Division of British Insulated Callender's Cables Limited.

A COMPLETE RANGE of AB De-ion moulded case circuit breakers for lighting, distribution and power circuit protection is described in a comprehensive new catalogue prepared by Canadian Westinghouse.

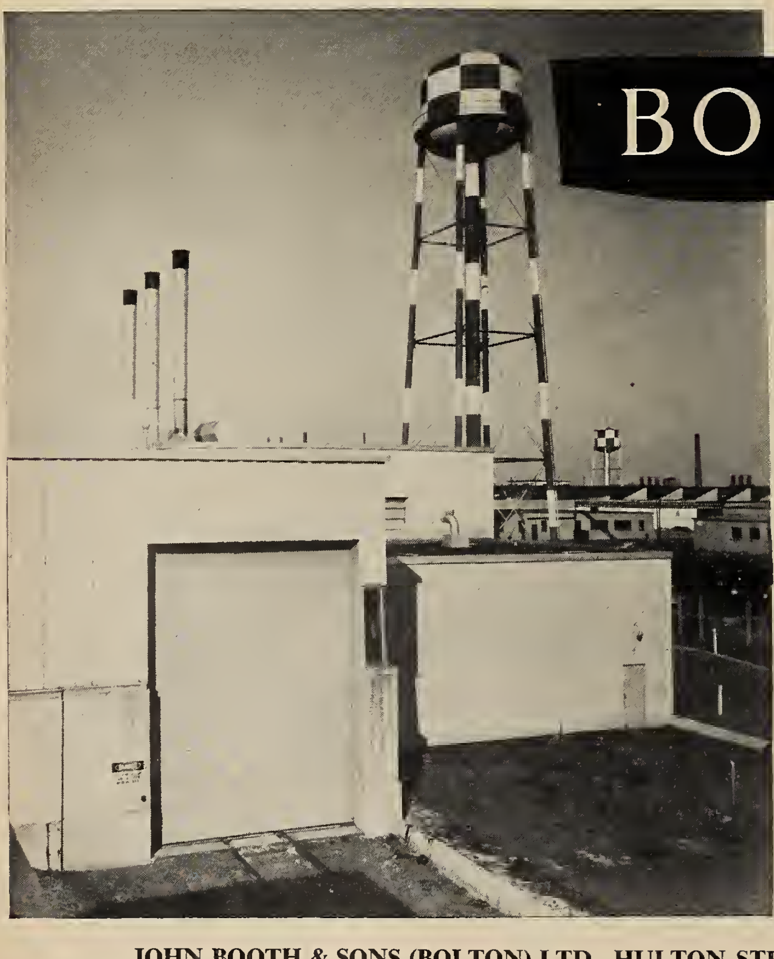
HEATING AND VENTILATING cabinets supplied by the Canadian Blower & Forge Company, Kitchener, Ont., are listed and fully classified in a new bulletin (UH-130).

THE HEAVIEST STEEL COLUMNS ever produced for an office building in the Commonwealth are now being erected at the site of the Cruciform Building in Montreal's Place Ville-Marie. Jointly fabricated and erected for the project by Dominion Bridge and Dominion Structural Steel, the columns weigh over a ton per lineal foot. "A start on the column erection confirms the fact that the initial steel work stage —installation of the steel base plates and grillages for the columns—is nearing completion," explained Quinton L. Carlson, construction manager for Webb & Knapp (Canada) Limited, the owners.

PROMISE OF A MARKET for 500,000 tons of asbestos fibre each year is offered by a research development announced by Johns-Manville. The special grade of fibre required for use in asphalt road paving can be made available in quantities far exceeding present demands, providing a surface that offers high speed and safety to the driver as well as long service and economy for the taxpayer. Total present production of asbestos fibre in the free world is estimated at 1.5 million tons yearly.

CYCLOTRON PERFORMANCES can now be predetermined by means of a magnetic field plotting system of unprecedented speed and accuracy. The new system, developed and placed in operation by Oak Ridge National Laboratory which is operated for the A.E.C. by Union Carbide, makes it possible to evaluate the detailed performance of a cyclotron before it is built. A well-coordinated mechanical and electronic system automatically programmes and positions a sensitive element which provides a voltage signal directly proportional to the strength of the magnetic field. The

• *More Briefs on page 164*



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• MORE BRIEFS

(Continued from page 158)

small size of the sensitive element, a wafer of semi-conducting material measuring 1/32" sq. in. area and known as the Hall probe, contributes much to the accuracy of the measurements.

MAN'S FIRST inhabited space station may be packed in a small container as it leaves the earth, blown into shape like a balloon when it leaves orbit, and made rigid by quick-setting plastic foam. Goodyear Aircraft Corporation engineers say that expandable coated fabric structures will make this possible. The fabrics, either of organic or metallic fibres, will be able to withstand high temperatures, extreme cold and the hard vacuum of space. Pre-fabricated sections will be folded into compact packages, boosted into orbit by ferry rockets, expanded by internal pressure and joined to other sections to erect the complete station. Similar expandable shelters may also be the first inhabited dwellings on the moon.

ANTI-SKID characteristics for paper bags and cartons, to reduce damage to goods during warehousing and shipping, can be achieved by Nalcoag 1050, a 50% colloidal suspension of silica in an aqueous solution announced by Alchem Ltd. of Burlington, Ont. This is the first 50% colloidal suspension of silica made available for commercial use. Nalcoag 1050 forms an exceptionally strong bond because of its very small particle size, the particles tend to fill in the minute pores and irregularities of the solid surfaces increase the surface to surface friction, and film strength, and reduce tack and the tendency to accept soil.

A SOLUTION to the difficulties long associated with accurate flow measurement of ethylene gas has been proven in field tests by General Electric using the Company's recently-introduced industrial mass flow-meter. General Electric engineers report it is now possible to measure ethylene flow directly in lb. with accuracy of within 1%.

CAREFUL BLASTING has overcome many difficulties in the formidable task of rebuilding the Trans Canada Highway from the Fraser Canyon in British Columbia. Close control of the muck pile has been achieved, using continuous application of the split second blasting technique with C.I.L. short-period caps. Generally the blasts have been hooked up in series-parallel circuits, care being taken to balance the resistance of the series and so minimize the possibility of misfires.

PACKAGED POWER in mobile and other lightweight generating equipment is offered by Dale Electric (Yorkshire) to provide electricity for specific needs in Canadian industry, communications, the farm or the home.

WITHOUT GRAVITY other than that artificially produced by rotation, great structural strength will not be required in space stations. This is the opinion of Goodyear Aircraft's Frank B. Sandgren, who maintains that the inflated structure for orbital flight will be safe and far lighter than a rigid frame, and will permit storage and transportation in minimum space for minimum weight.

BEST PERFORMANCE and longest service life from industrial storage batteries can be obtained by following the right operating rules. This is what has prompted the Electric Storage Battery's Exide Industrial Division to issue a comprehensive instructional manual, which includes directions for minor repairs.

TWO AUTOCLAVES are being built by the Sparling Tank Company for J. Cook Concrete Block Company of Aldershot. Hot oil heating coils will line the bottom of the autoclaves. The coils will be covered with water and as oil temperature is raised to 550°F the steam from the boiling water will cure the blocks. Substantial savings are expected. Because the hot oil will be under 15 lb. pressure, a stationary engineer will not be required.

"THE DANGEROUS DELUSION" that Canada is fast becoming an industrial nation was criticized by Herbert H. Lank, Du Pont president, at the Company's annual meeting. Urging his listeners to buy Canadian, he pointed out that while the manufacturing industry had grown considerably since 1940 its relative importance in the economy had not changed. In 1940, manufacturing accounted for 26.7% of gross domestic product; in 1958 it was 26.3%.

THE SHELL is the secret of the new long period delay blasting cap introduced by C-I-L. Elimination of the vent hole common to previous slow delays practically eliminates water and air hammer failures and the shorter, rigid shell facilitates priming of explosive cartridges.

THE ENGINEERING JOURNAL

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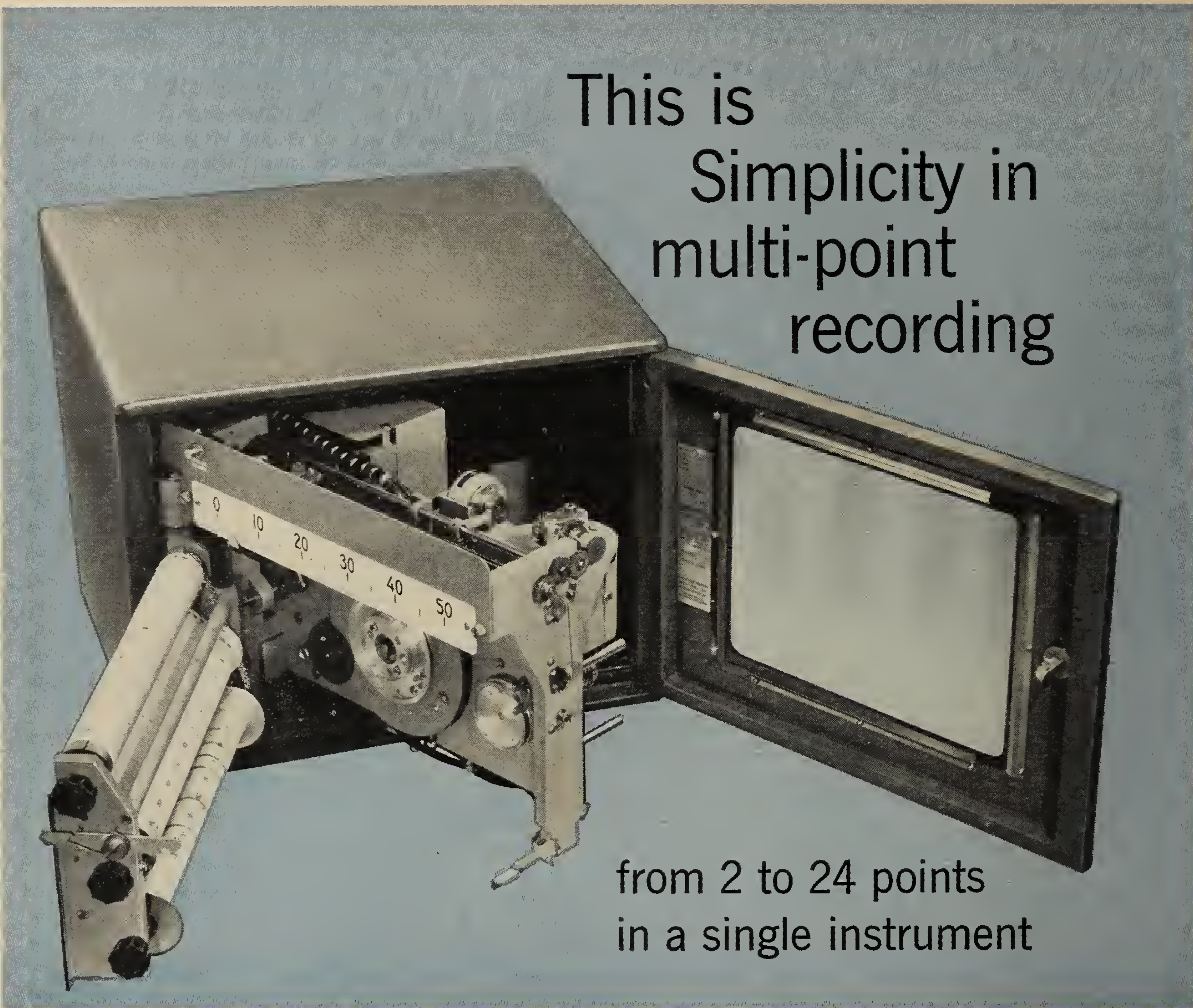

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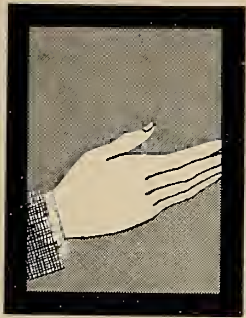

Meet the Authors

A. G. L. McNaughton, M.E.I.C., B.Sc., (McGill '10), M.Sc., Hon.-LLD., Chairman, Canadian Section, International Joint Commission, Ottawa. *(Pollution in the Boundary Waters of Canada).*

Upon his retirement from the Canadian Army, General McNaughton was appointed Minister of National Defence (Nov. '44-Aug. '45). In 1946 he served as Canadian Representative, U.N. Atomic Energy Commission and was for two years President of the Atomic Energy Control Board of Canada. He was Permanent Delegate of Canada to the U.N. and Canada's representative on the Security Council from January 1948 to January 1950. He is a past president of the National Research Council.

J. R. Menzies, B.A.Sc., (Toronto '26), Chief, Public Health Engineering Division, Department of National Health and Welfare, Ottawa. *(Pollution in the Boundary Waters of Canada).*

For two and a half years after graduation Mr. Menzies was employed on land surveys and townsite work, after which he joined the federal health department. He was appointed to his present position in 1948 and has participated in several studies of pollution problems as chairman or member of advisory boards appointed by the International Joint Commission.

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Mr. Berry is a member of the American Society of Civil Engineers, the American Water Works Association, the Association of Professional Engineers of B.C., the Water Pollution Control Federation and is a Diplomate of the American Academy of Sanitary Engineers.

P. H. Bouthillier, M.E.I.C., B.Sc., Civil (Alberta '44) S.M. (Harvard '47), Associate Professor of Civil Engineering, University of Alberta, Edmonton. **H. L. Hogge,** M.E.I.C., B.Sc., Chemical (Alberta '50), Provincial Sanitary Engineer, Department of Public Health, Government of Alberta, Edmonton. *(Stream Pollution and its Control in Alberta).*

Professor Bouthillier has been on the staff of the University of Alberta since 1947. He has also worked with the Alberta Department of Health, Division of Sanitary Engineering in connection with pollution studies.

Mr. Hogge has been with the Alberta Department of Public Health since his graduation. He has been involved in stream pollution studies, municipal engineering work and has been Director of the Division of Sanitary Engineering for six years.

N. S. Bubbis, M.E.I.C., B.Sc., Civil (Manitoba '34), General Manager and Chief Engineer, Greater Winnipeg Water and Sanitary District, Winnipeg, Manitoba. *(The Greater Winnipeg Sanitary District and River Pollution Abatement).*

Mr. Bubbis started work with the City of Winnipeg as a pipe plant inspector; he later became Engineer-in-Charge of the drafting and designing branch, and then Engineer of Water Works and Sewerage. He is a past president of the Association of Professional Engineers of the Province of Manitoba, the Canadian Institute of Sewerage and Sanitation, the Western Canada Water and Sewage Conference and the Minnesota Section of the American Water Works Association.

A. E. Berry, M.E.I.C., B.A.Sc. (Toronto '17), M.A.Sc., C.E., Ph.D., General Manager, Ontario Water Resources Commission, Toronto, *(Advances in Sewage and Waste Treatment).*

Dr. Berry was formerly the Director of the Sanitary Engineering Division of the Ontario Department of Health and had charge of water works, sewage works, and all environmental sanitation throughout the province. He is Past President of the American Water Works Association and the Water Pollution Control Federation and a member of other technical and professional organizations.

A. M. Snider, M.E.I.C., B.A.Sc. (Toronto '17), Chairman, Ontario Water Resources Commission and President, Sunshine Waterloo Co. Ltd., Waterloo, Ontario. *(The Ontario Plan for Water Pollution Control).*

Mr. Snider served as Design and Production Engineer of Canadian Ingersoll Rand Co. Ltd., Sherbrooke; later as Chief Engineer and Assistant General Manager, Waterloo Manufacturing Co. Ltd.; and then successively as General Superintendent, General Manager and President of the Sunshine Waterloo Co. Ltd. He was the first Chairman of the Water Resources Committee of South Western Ontario as well as the Chairman of the Ontario Water Resources and Supply Committee.

Leopold Fontaine, B.Sc., Civil (Ecole Polytechnique '30), Assistant Chief Engineer, Quebec Ministry of Health. **Jean Paul Gourdeau,** B.Sc., Civil (Ecole Polytechnique '51), M.Sc. (Harvard), Sanitary Engineer, Quebec Ministry of Health. **R. R. Carrier,** JR.E.I.C., B.Sc., Civil (Ecole Polytechnique '48), Sanitary Engineer, Quebec Ministry of Health, Quebec City. *(Aspects of River Pollution in the Province of Quebec).*

Mr. Fontaine has worked for the Quebec Ministry of Health since his graduation. He is also a professor in Sanitary Engineering at Laval University. Mr. Fontaine is a member of the Corporation of Professional Engineers of Quebec, the American Water Works Association, the Water Pollution Control Federation, and the American Public Health Association.

Mr. Gourdeau is a councillor of the Corporation of Professional Engineers of Quebec and a member of the American Water Works Association and the Water Pollution Control Federation.

Upon graduation, Mr. Carrier worked as a design engineer. He then took post graduate studies at Harvard in Sanitary Engineering and joined the Quebec Ministry of Health in 1952. At present he is also a Professor of Sanitary Engineering at Sherbrooke University. He is a member of the American Water Works Association, and the Water Pollution Control Federation.

A. L. Van Luven, M.E.I.C., B.Sc., Chemical, (Toronto '48), Head, Waste Treatment Division, H. E. McKeen & Company Ltd., Lachine, Quebec. *(A Study of the Use, Conservation and Pollution of Water Resources).*

Mr. Van Luven spent several years prospecting and mining in the Northwest Territories and Quebec. He was also with Canada Packers Ltd. for ten years. He is a member of the Chemical Institute of Canada, The Canadian Institute on Sewage and Sanitation and the American Water Works Association.

T. W. Beak, Consulting Biologist, Collins Bay, Kingston, Ontario. *(The Measurement of Industrial Water Pollution).*

Mr. Beak graduated from London University (England) and held several government posts in the U.K. in the fields of chemistry and biology. He came to Canada in 1955 and set up consulting practice in industrial water pollution problems. He is the Eastern Canadian representative on the Pollution Committee of the American Fisheries Society.

COVER ILLUSTRATION

Water pollution is truly nebulous. Its presence is a matter of degree, and it is no more tractable to preconceived ideas than the fabulous many-headed snake of the mythical marshes. Our June authors tackle this modern Hydra by painstaking analysis of its many constituent problems.

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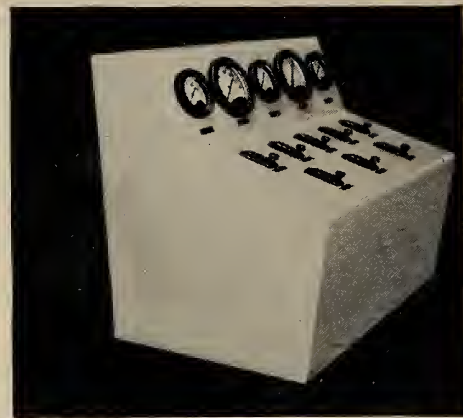

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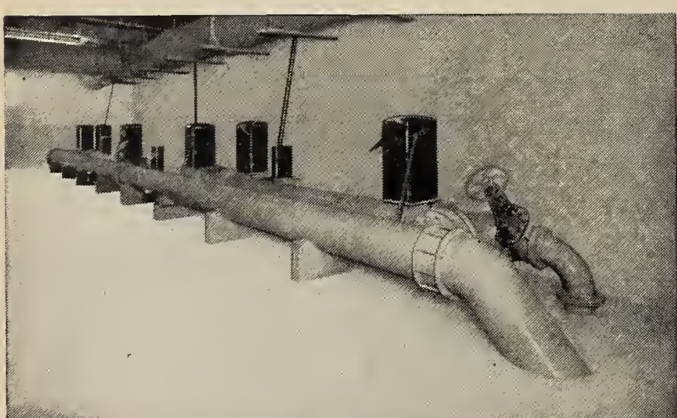

Below the operating floor, eight Bailey Drives operate Butterfly Valves to control water flow to and from the process.

ALL PHOTOS TAKEN AT THE BRANDON WATER PLANT BRANDON, MANITOBA.

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Message from the President

FOR MANY YEARS the Institute has been Canada's national technical organization of engineers. As such it has endeavoured to present, both to Canada and to the world, a true and complete picture of the engineering activities in this country.

Today this effort is more important than ever before, and your Institute must take an even more prominent part in this most important duty, through its technical meetings, publications, and active participation in national affairs and international engineering activities.

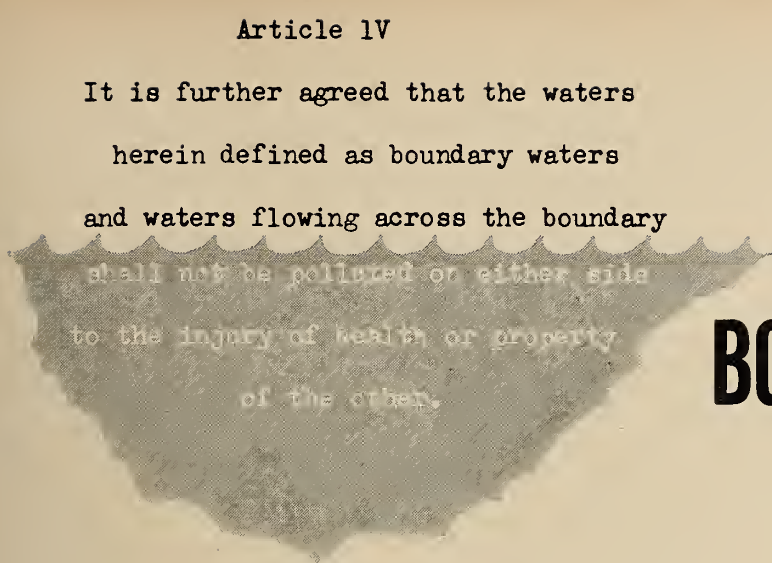
Engineering achievements in Canada represent major advances in technical development, and we must see that these advances are made known both within and beyond our geographic boundaries. The Institute also has an important responsibility of encouraging and directing its members in the presentation of its accomplishments so that maximum benefit is obtained from their effort.

In selecting me for the position of President of the E.I.C. for the ensuing year, I am deeply appreciative of the great honour which has been conferred on me. I am also keenly aware of the deep responsibilities which fall upon me as your President. During my many years of association with the Institute I have enjoyed numerous opportunities for congenial technical and social fellowship, and I feel sure that in my new relationship to the Institute I will find even greater opportunities for the development of this friendly atmosphere.

During the past year as Vice-Chairman of the Engineers Confederation Commission, it was my privilege to have been associated with John Fox and his devoted Commissioners, in the work of implementing Confederation. To this group I extend my sincere thanks and best wishes for a successful continuation of their efforts in this important task.

GEORGE McKINSTRY DICK, M.E.I.C.

President, 1960-61
The Engineering Institute of Canada



POLLUTION IN THE BOUNDARY WATERS OF CANADA

J. R. Menzies
Chairman, Canadian Section, Advisory Boards to the International Joint Commission on Control of Pollution of Boundary Waters.

A. G. L. McNaughton, M.E.I.C.
Chairman, Canadian Section International Joint Commission.

Consideration of pollution and measures for its control in Canadian boundary waters would be incomplete without some reference to conditions in the adjacent boundary waters of the United States. The corollary is also true. The importance of this approach to the problem was recognized many years ago when a "Treaty between the United States and Great Britain relating to Boundary Waters and Questions Arising between the United States and Canada" was signed on January 11, 1909. This Treaty, commonly referred to as The Boundary Waters Treaty, authorized the appointment of an International Joint Commission (Article VII) with three members from each country.

ARTICLE IV of the Treaty states in part that "It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other".

Under Article IX of the Treaty each country agreed to refer to the International Joint Commission for examination and report with appropriate recommendations any questions "involving the rights, obligations, or interests of either in relation to the other or of the inhabitants of the other". It is under this Article that questions involving the pollution of boundary waters have come before the Commission.

Regarding the use of boundary waters, Article VIII of the Boundary Waters Treaty states, in part, as follows: "The following order of precedence shall be observed among the various uses enumerated hereinafter for these waters, and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of precedence;

1. Use for domestic and sanitary purposes;
2. Use for navigation, including the services of canals for the purposes of navigation;
3. Use for power and for irrigation purposes".

It will be noted that there is no mention made of use for industrial purposes. It might be assumed that it was intended to fall in the first classification on the basis that industry is usually located in urban communities. It seems likely that if the Boundary Waters Treaty were revised now, industrial water use would be mentioned specifically because of the increasing tendency for large industries to locate outside urban communities.

Investigation of pollution by the International Joint Commission ordinarily is initiated by an appeal to their federal government by those who suffer from the effects of pollution. When the two federal governments agree that the matter should be referred to the Commission, a Reference is drafted by the State Department, for the United States, and the Department of External Affairs, for Canada. The State and Provincial governments which may be involved, are kept fully informed of developments and are afforded opportunities to discuss the problem and the terms of reference. When agreement has been reached regarding the terms of the Reference the Commission is requested to investigate and report upon the matter and to make appropriate recommendations to the two federal governments.

In carrying out its investigations the Commission normally appoints a Board of Technical Advisers to direct the field work and all related duties. The Board members are selected from the staff of federal, state and provincial governments on the basis of their special knowledge or training in the field of pollution control.

Problems involving transboundary pollution have been under reference to the International Joint Commission on several occasions. The first of these was in 1913 and posed the question "To what extent and by what causes and in what localities have the boundary waters between the United States and Canada been polluted so as to be injurious to the public health and unfit for domestic or other uses?" The study which was undertaken extended from the Lake of the Woods through the Great Lakes and connecting waters, the international section of the St. Lawrence River and to the international section of the Saint John River. Most of the analyses were for the purpose of determining the intensity of bacterial pollution and the resulting report noted extensive areas which were, at that time, considered to be seriously polluted, particularly the rivers connecting the Great Lakes and adjacent areas of the lakes affected by pollution brought into them by these rivers.

The Commission reported to the two governments under date of 12 August 1918 that the discharge of sewage in its raw condition into boundary waters had "resulted in a situation along the frontier which is generally chaotic, everywhere perilous and in some cases disgraceful. The Common law having proved inadequate to the task of controlling affairs, it has been supplemented or superseded by legislative enactments, which in their practical working have about as signally failed". (Page 31). The Commission recommended that the necessary jurisdiction and authority in respect to the pollution of boundary waters and waters crossing the boundary be conferred upon it; and for the purpose of giving effect to the jurisdiction and authority so conferred that the Commission be authorized to make such rules, regulations, directions and orders as in its judgment may be deemed necessary; and that power be also given to the Commissioners to appoint such engineers and employees as it may consider advisable. (Page 50).

Further Analysis

When these proposals came to be further analysed and considered by the Governments it became evident that the creation of such an international authority with comprehensive powers and jurisdiction in Boundary Waters would not represent a practicable solution, and hence no action was taken. However, with the worsening of pollution which was evident in the connecting channels of the Great Lakes System, the International Joint Commission received a further reference on 1 April 1946, concerning conditions in the St. Clair River, Lake St. Clair, and the Detroit River. This reference was extended on October 2, 1946, to include the St. Marys River. and on April 2, 1948, to include the Niagara River. The Commission was asked to ascertain whether any of these waters were being polluted on either side of the boundary to the injury of health or property on the other side and if so, to what extent, by what causes and in what localities; and to recommend the most practicable measures for remedying the situation.

Extensive and detailed studies were undertaken in the areas mentioned and in adjacent waters of the Great Lakes. These studies included many types of analyses and observations which were not made under the 1913 Reference. The results were set forth in the Report of the International Joint Commission on the Pollution of Boundary Waters which was transmitted to the Governments of the United States and Canada under date of October 11, 1950.

Objectives

Incorporated in the report just mentioned, was a section entitled "Objectives for Boundary Waters Quality Control". The Commission recommended that these Objectives "- - - be adopted by the two Governments as the criteria to be met in maintaining boundary waters in satisfactory condition, as contemplated in that portion of Article IV of the Boundary Waters Treaty of 1909 wherein it is stated: 'It is further agreed that the waters herein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health and property on the other'."

The Commission further recommended " - - - that it be specifically authorized by the two Governments to establish and maintain continuing supervision over boundary waters pollution through boards of control appointed by the Commission", and to bring to the attention of the competent authorities in the respective countries any pollution found objectionable in the light of the "Objectives".

It is of interest to contrast this recommendation with that which had been made in 1918. Instead of asking for unlimited jurisdiction over pollution, the Commission proposed that governments themselves should adopt specific objectives for boundary waters quality control and that the Commission's duties should extend only to the more modest function of continuing supervision.

In contrast to the fate of the 1918 Reference, the Commission's report of October 1950 was promptly accepted by the Governments. In so doing the merits of the "Objectives for Boundary Waters Quality Control" were recognized at the highest level and subsequent experience has indicated that they were worthy of this endorsement. Several governing bodies, such as the Ontario Water Resources Commission, have adopted the "Objectives" officially or have accepted them as a guide in pollution abatement and control activities.

Shortly after the adoption of the Pollution of Boundary Waters Report, the International Joint Commission appointed Advisory Boards on the Control of Pollution of Boundary Waters in the Great Lakes System and these boards have functioned continuously since then. Their duties have included follow-up studies in the boundary waters and the submission of semi-annual reports to the Commission reviewing all matters of interest in the areas studied under the terms of reference already noted. The Commission has therefore been currently informed of any situations in which the objectives had not been complied with and thus is able to bring these to the attention of the Federal, State, Provincial or Municipal authorities concerned for appropriate action.

Industrial Wastes

A very important phase of control activities has to do with industrial wastes, their effect on boundary waters, and the treatment of objectionable wastes. These activities will be discussed in some detail later.

Another reference to the International Joint Commission was dated June 10, 1955, and was related to the St. Croix River, a considerable portion of which flows along the boundary between the Province of New Brunswick and the State of Maine. Originally it was thought that since it had to do largely with the potential development of the river basin, pollution would not be of great significance. It was quickly realized, however, that pollution was of major concern and would need to be resolved since it was intimately related to many other facets of proposed future development in the basin. Studies were undertaken to evaluate conditions caused by it. Again the Commission has recommended the adoption of "Objectives for Boundary Waters Quality Control" with the addition of an "objective" for dissolved oxygen. This was necessary since restoration of anadromous fish runs was one of the proposals related to future development of the area and dissolved oxygen in the river waters was being seriously depleted by industrial and other wastes in the lower reaches of the river.

The International Joint Commission now has before it a further reference dated May 30, 1959, necessitating a study of pollution in the Rainy River which flows along the international boundary between the State of Minnesota and the Province of Ontario. The Commission has appointed an Advisory Board and detailed studies are being undertaken this year. This is basically a pollution problem although other interests affected by pollution, such as recreation and fish propagation, are intimately involved.

Many other water use problems are under reference to the Commission involving irrigation, power development and control of water levels and flows. Pollution has not been a significant factor in these instances and consequently has had little or no detailed consideration.

To achieve an understanding of pollution in boundary waters it is essential to review developments which were foreseen when the Boundary Waters Treaty was signed.

There is a popular slogan, "Misuse is Abuse". The conditions which have developed or exist might suggest that misuse itself has been an "objective" and, as such, has been eagerly endorsed by many interests. The need for water pollution references to the International Joint Commission emphasizes the fact that in some areas pollution is so severe that it affects citizens and communities on the other side of the international boundary. The complaints may be due to different sources and degrees of pollution. For example, pollutants which cause tastes and odours in public water supplies are significant because so many people are affected by them.

Phenolic compounds, which are frequently present in industrial wastes of various kinds, are incriminated rather often, because objectionable tastes result when they combine with chlorine. Similarly some industrial wastes, such as cyanides, and gross pollution by municipal wastes, are responsible for fish kills, and these receive much publicity because the dead fish frequently become stranded along the shoreline. Of major significance to everyone is pollution from municipal wastes. Prior to the develpment of modern water treatment methods, this form of pollution was of grave importance because many epidemics of water-borne disease were traced to water which was being polluted by human wastes. It still is most important, but too often a false sense of security prevails. Only continuous and conscientious attention to detail by waterworks personnel prevents an upsurge of water-borne disease which would reap a terrible harvest from the fields of careless and thoughtless waste disposal.

New products and processing methods are creating waste treatment problems of increasing complexity. These problems are accentuated by the rapid increase in population, the trend to urban living and increases in the use of water for many purposes, all of which increase pollution and tend to extend it further afield or overload waste treatment facilities, when they exist. The need for finding satisfactory solutions to the resulting problems has been recognized earlier and to a greater degree in the United States than in Canada, largely because of earlier experience with intensive industrial development there and greater density of population. It must be realized that prevention of pollution is better and usually less costly than correction.

Responsibility

The localized nature of pollution problems in Canada cannot and must not be a basis for complacency. While the basic responsibility for control of pollution is that of provincial authorities, a great deal can be done by federal agencies to encourage corrective action. Finally the individual citizen, because he must pay the bill, has a great and leading role to play by accepting financial obligations for the correction of faulty waste disposal methods.

The International Joint Commission's duties are essentially those of a co-ordinating agency which seeks at all times to facilitate the solution of pollution and other problems in international waters which could evolve, if left untended, into matters of international concern. There have been many examples of such situations. One which is associated with the Boundary Waters Reference of April 1, 1946, will serve as an illustration. The City of Detroit, prior to that time, had been experiencing objectionable tastes in its municipal water supply which is taken from the upper reaches of the Detroit River. The municipal authorities suspected that their problems were associated with industrial development in Canada near the City of Sarnia. The studies which were undertaken by the Commission revealed that excessive amounts of pollutants were being discharged by industries in the Sarnia area but it was also demonstrated that taste-producing substances, such as phenols, were entering the boundary waters, above the City of Detroit intake, from industries in Michigan. It was also shown that wastes in the St. Clair River, Lake St. Clair and the Detroit River were crossing the international boundary from each side.

A wide range of remedial actions was initiated following the investigations, and indeed these are still in progress. With very few exceptions the response of industry has been most gratifying and succesful in its accomplishments. In large sections of the boundary waters, compliance with the "Objectives for Boundary Waters Quality Control" has been achieved. A great deal has been accomplished in respect of municipal waste treatment but there are still quite a few municipalities without treatment facilities. Many of these are now planning remedial measures and early completion of this phase is anticipated.

In spite of these improvements much remains which requires corrective action. The need for this extends beyond the connecting waters of the Great Lakes into the Lakes themselves. Data concerning the presence of phenolic materials in Lake Erie indicate that much of the lake fails to meet the "Objectives for Boundary Waters Quality Control". This condition can be corrected in only one way, that is by the treatment or control of the wastes themselves. The condition of Lake Erie is reflected in the Niagara River which, in spite of corrective action by industries in the immediate area, still contains excessive amounts of phenols. This demonstrates beyond question the need for closely co-ordinated control action throughout the boundary waters. Those industries and communities which have responded to appeals for corrective measures can gain little comfort from the knowledge that their leadership is appreciated if, at the same time, it is obvious that others are failing to take similarly effective action.

It is not unusual to hear the plea "Why should we provide treatment facilities when our neighbour shows no indication of doing anything?" The answer is obvious but not too satisfactory—"Someone must be first". Even with the best intentions by all, the race to preserve water quality may well be lost before it starts. It is so difficult to realize the need or the urgency involved. The taxpayer who has no interest in waste treatment is protected in his folly by the best efforts of those who are charged with the duty of protecting his health and property. No doubt the citizen has many ways of spending his money which hold greater appeal to him than waste treatment. If, however, his drinking water supply has a vile taste or he cannot safely swim at his favorite beach, or the fish he had hoped to catch are killed before his eyes, he begins to see the problem in its true perspective. Even then he may have no conception of the degree of urgency or the methods of correction. We must have leadership and guidance but most of all we must realize that "Misuse is Abuse".

Remembering that many of our present problems are of recent occurrence it would be fitting to most sincerely acknowledge the wisdom, foresight and statesmanship, evidenced by the makers of the Boundary Waters Treaty over fifty years ago.

POLLUTION CONTROL IN THE LOWER MAINLAND COMMUNITIES OF BRITISH COLUMBIA

T. V. Berry, M.E.I.C.
Commissioner, Greater Vancouver Water and Sewerage and Drainage Districts.

The nuisances which the nineteenth-century combined sewer removed from the close proximity of residences were transferred to the streams and rivers which flowed nearby. First the smaller and then the larger bodies of water unable to cope with the digestion of the ever increasing waste matters became areas, especially in hot weather, of fermenting liquid and nauseous vapors. Out of these insanitary conditions came the separate systems of sewage transmission and the treatment of dry weather flows in scientifically designed plants intended to make innocuous and easy the final disposal of sewage. And so matters are different today. While sewage disposal is expensive, next to a pure and abundant water supply the public demands efficient disposal without degradation of streams and lakes or ocean fronts. But the problem of water pollution in North America has grown more intense with increase in concentrations of population, greater use of water and the large quantities of wastes attendant on modern industrial processes characterized by high concentrations of chemical and biochemical matters. In many areas the pollution of streams has reduced the available lakes and streams to a point of degradation where their safe use has been jeopardised if not entirely destroyed. This deals with the progressive pollution of streams and adjacent tidal waters in the Lower Mainland communities, past legislation on the problems of pollution and the measures now being undertaken which are expected in the few years ahead to reduce pollution to well within conservative and tolerable limits.

THE LOWER Mainland communities lie astride the Fraser River as it flows from the Municipality of Hope near where the river debouches from its canyons to the tip of Point Grey on the Strait of Georgia and from the International Boundary northerly to the mountains of the Coast Range. This land and water mass has an area of 9,000 sq. miles and is approximately coincident with the administrative area of the Pollution-control Board described in later pages.

The easterly two thirds of the area supports many small communities depending primarily on agriculture and its ancillary industry. The westerly one-third is more heavily populated and in this section are situated the Burrard Peninsula communities, the City of Vancouver, the City of New Westminster and the Municipality of Burnaby. In addition a number of lusty and rapidly growing municipalities adjoin the two trans-continental railroads and the highway systems which serve the Fraser Valley. These cities and municipalities to a great extent depend on the management of the basic industries of the Province and its manufacturers of secondary commodities.

For a better understanding of the problems of water pollution in the area defined above we shall describe briefly the geography, areal development, geology, climatology and domestic water supply of the region.

Geography and Areal Development

The Fraser River flowing through this area is one of the principal rivers tributary to the Pacific Ocean on the North American Continent. The maximum recorded flow of the river is well over 500,000 c.f.s. and the minimum is 30,000 c.f.s.

Upstream from its mouth the Fraser River divides into two main channels — the North Arm and the main channel. The delta land formed between the two arms constitutes the Municipality of Richmond — for many years given over to dairying and small fruit farming. It is now rapidly developing into an urban and industrial community. Vancouver International Airport, a very busy, if not the busiest airport in Canada, occupies a major portion of Sea Island — one of the islands constituting the delta.

The most rapid development of the area under discussion is largely along the westerly end of the Lower Mainland communities. Most of the residential development as well as a major part of commerce and industry is centred in the City of Vancouver but the easterly end of the Burrard Peninsula is rapidly expanding both industrially and residentially — notably in the Municipalities of Burnaby and Coquitlam.

The North Shore communities are predominantly residential but industry is developing along the whole shore of Burrard Inlet east of the First Narrows. Industrial development of the Lower Mainland is now centred on the shores of Burrard Inlet, the North Arm of the Fraser River and on the Fraser River itself to some distance east of New Westminster. Industry consists in the main of lumber and wood products, meat slaughtering and packing, vegetable and fruit packing, petroleum refining, fish processing and canning. Shipping which centres in Vancouver Harbor is an important industry. It transports grain, lumber and timber products, machinery and fish products to all parts of the world. The lands marginal to the Fraser River from the Strait of Georgia to New Westminster and beyond will be developed to a greater extent than now as conditions in the Orient become more stable. The approximate population of the Lower Mainland cities, municipalities and villages at the end of 1959 is estimated at 854,000. This is approximately 54.5% of the population of the Province of British Columbia which is estimated at 1,570,000 at that date.

Topography and Geology

The Lower Mainland area, except the Fraser River delta islands, is largely a varied terrain of rolling hills and mountains. Cut through by the Fraser River as it flows westerly, and indented by Burrard Inlet, the major salt water harbor, the area is characterised by ample grades for discharge of sewage and drainage to the nearest waterways except in the delta lands of the Municipalities of Richmond and Delta.

The characteristic geologic formations in the area are tertiary sediments comprising layers of sandstones, shales and conglomerates in various thicknesses. These lie on the old granitic rocks of the Coast Range batholith of intruded igneous rock. The tertiary sediments are in most cases overlain by glacial and interglacial deposits of thicknesses up to 250 ft. In addition these are in places overlaid by delta deposits of the Capilano, Seymour and Coquitlam Rivers and the Fraser River and its tributaries.

Climate

The climate of the area is a mild one without extremes of temperature. Winds normally are light to medium. Precipitation is relatively high, mostly as rain varying from 37 in. at Vancouver Airport to as high as 150 in. at the mountains north of Burrard Inlet.

Water Supply

In general the major water supply of these communities is from surface water emanating from the creeks and rivers with their sources in the Coast Range mountains to the north. With the prolific rainfall in the area and generous storage in the form of snowfields in the mountains for summer use, the area is well endowed with water potential for large populations.

Twelve cities and municipalities west of the Pitt River and two east of it receive their water from an inter-municipal corporation known as Greater Vancouver Water District. This corporation supplies, *at cost*, these member municipalities and several unorganized areas with water to their boundaries by gravity from three sources of supply namely: Capilano, Seymour and Coquitlam Rivers. The average daily per capita use of water over the entire district is between 130 and 140 imp. gal.

These three rivers have catchment areas totalling 226 sq. miles. About 20% of the land in the watersheds is owned outright by the Water District. The balance is leased to it by the Crown for a period of 999 years for water supply purposes. These watersheds are situated in the mountains to the north and are regions covered with heavy timber growth. No residential or industrial development is permitted within them and the public is excluded by regulation posted at the several places of entry and by patrolling. Hikers, fishermen and mountaineers are excluded also from these rugged catchment areas. Reference will be made later to the sanitary significance of these conditions.

Recreational Facilities in the Lower Mainland

The Lower Mainland has valuable recreational facilities in the form of many miles of good beaches. These beaches probably aggregate 15 to 20 miles in extent. It is estimated that these are visited by 2,000,000 visitors, residents and tourists alike during a normal summer, who enjoy to the full sunbathing, swimming and water skiing.

The mountains to the north, outside the catchment areas reserved for water supply, give opportunities for skiing to thousands of enthusiasts for some five months of the year. The lower reaches of the Capilano and Seymour Rivers, the many lakes in the area and the tributaries of the Fraser River supply excellent salmon and sport fishing.

It is estimated there are over 30,000 power operated boats, commercial fishing and pleasure craft owned and operated in the Lower Mainland waters.[1] The pleasure craft ply the waters adjacent to the Lower Mainland during the summer recreational months and the fishing, tugboat and other commercial craft ply these waters for most of the year.

The mountains to the north of the Fraser afford many excellent climbing areas to mountaineering enthusiasts and golfing is enjoyed practically all the year around on a number of very fine privately owned and public links.

Condition of the Shore and Shore Waters

Virtually all of the municipalities constituting the Lower Mainland have rivers or ocean shores adjacent to them into which sewage can discharge, and it is a matter of good fortune that these communities are not dependent on these bodies of water for their domestic and industrial water supplies.

The danger of these water supply streams becoming polluted therefore, need not occur if intelligent and prudent care is exercised in the management and use of them.

The pressing problem in the Lower Mainland is hence not one of pollution of water supplies but of abatement and prevention of pollution of those streams and bodies of water on which the community depends for recreational, commercial and game fishing, and for the protection of the hygienic and aesthetic aspects of the waters and marginal shores.

At present crude sewage is discharged without treatment into ocean and river waters of the Greater Vancouver area (from Coquitlam to Point Grey) at about 65 known locations. Altogether there are probably over one hundred such outfalls from the Village of Hope to Point Grey, including English Bay and Burrard Inlet. Many of these outfalls discharging crude sewage are adjacent to important beach and recreational areas. In addition there are large contributions of sewage to the waters by ocean-going vessels, the thousands of pleasure and fishing craft and float houses—of which there are many in Burrard Inlet. The towing of millions of feet of logs in large booms into the estuary of the Fraser River from up-coast logging operations adds its quota of flotsam to these waters.

A number of water bodies in the Lower Mainland, evaluated by testing for bacteriological condition and by visual and chemical examination of the waters, are undoubtedly moderately polluted. These are:

Port Moody Bay at the easterly end of Burrard Inlet: The land surrounding the head of the Bay is rapidly being built up both industrially and residentially. The problem of pollution in this area is rapidly growing. A sanitary sewer collecting system and primary treatment facilities is now under construction here to prevent pollution becoming serious.

The North Arm of the Fraser River: Pollution in this body of water

1. Estimate of Registrar of Shipping, Vancouver, B.C.

is recorded by the B.C. Research Council report on "Water Quality in the Fraser-Thompson River System, 1950" as being moderately polluted.[2] Plans of the Greater Vancouver Sewerage and Drainage District call for interception of sewers discharging into this body of water and eventual treatment in the Iona Island plant now under construction. This provision however, does not effectively deal with pollution by sewage in the North Arm originating from Richmond and New Westminster.

Head of False Creek: In due course the several sewers discharging into these waters are to be pumped to sewers leading to the Iona Plant.

English Bay (Kitsilano Beach, Locarno Beach, Spanish Bank, English Bay Beach, First, Second and Third Beaches): These beaches are polluted by water from the head of False Creek and sewage from the Discovery Street Outfall. However, comminution and chlorination of the raw sewage from the latter during the 1959 recreational season kept the beach waters in tolerable and acceptable condition pending the completion of the Iona Sewage Treatment Plant.[3]

Several other localities show mild pollution. These are usually in the vicinity of sewage outfalls, and as these sewers are intercepted and the effluent directed to treatment plants or better points of discharge, it is expected these conditions will be abated.

The Fraser River from Hope to New Westminster shows relatively light coliform counts and very little oxygen depletion. The water is subjected however during the spring and early summer freshets to heavy turbidities which discolour the waters of the estuary of the river and for some distance out into the Strait of Georgia. These discoloured waters during May, June and July intrude into the bathing areas of the south side of English Bay and undoubtedly add to the decadence of these waters evident during these months. (Fraser River flows estimated at New Westminster indicate during a five-year period October 1947 to September 1952, a minimum daily flow of 26,000 c.f.s. and a maximum of 665,000 c.f.s.).

History of Sewerage in the Lower Mainland Communities

The earliest sewers constructed in the area were laid by the City of Vancouver in 1890. Rapid growth in the Burrard Peninsula area (Vancouver, Burnaby, Port Moody, City of New Westminster and University Endowment Lands) during the first decade of the century, stimulated a scientific study and report of the problems of disposal of both sanitary sewage and surface water.[4] Mr. R. S. Lea of Montreal, a member of the Engineering Institute of Canada and well remembered by older Canadian engineers, carried out the study in 1911, 1912 and 1913 and made recommendations to the Burrard Peninsula Joint Sewerage Committee in 1913. The most important recommendations of Mr. Lea were substantially as follows:

1. That the principle of the separate system of sewers be adopted in the areas draining into English Bay, False Creek and Burnaby Lake;
2. That the most suitable points of outfall are:
   (a) Into English Bay on the line of Imperial (now Discovery) street;
   (b) Into Burrard Inlet (Vancouver Harbor) at Clark Drive and other points;
   (c) Into the Fraser River (North Arm);
3. That the interception of floating matter is essential for sewage discharged into English Bay and Burrard Inlet and that there is a possibility of some form of treatment being required in the future for sewage discharged into the Fraser River or its North Arm.

The master plan indicated the sewerage works in considerable detail which, in due course, would need to be provided.

Vancouver and Districts Joint Sewerage and Drainage Board was constituted by Provincial statute in 1913 and charged with the "carrying out of a system of sewage for the area within the Burrard Peninsula in substantial accordance with the Lea Report of 1913". The Province of British Columbia guaranteed its debentures up to $10.5 million. This amount was never completely expended before the Board was reconstituted by statute in 1956.

In 1913 the Attorney General of the Province retained Messrs. C. H. Rust and R. H. Thompson, Consulting Engineers, to report on the proposed enabling legislation constituting the "Sewerage District" and in addition to issue a satement regarding the proposed sewerage scheme "as being feasible and practicable".

These two gentlemen approved of Mr. Lea's "exercising great caution in the matter of polluting any of the waters whether fresh or salt, upon which any of the municipalities bordered and that so far as the scheme is concerned it is safe, feasible and practicable". They continued—"However we believe that he has over-estimated the danger of polluting the various waters referred to and has therefore laid more stress than conditions justify upon the necessity and propriety of constructing the drainage system of that portion of the district discharging into English Bay on what is known as the separate system . . . etc."

In the light of this criticism, Mr. Lea's recommendation as to constructing the English Bay System as a separate system was not adopted and virtually all of the trunks built over the years in the Burrard Peninsula by Vancouver and Districts Joint Sewerage and Drainage Board and the City of Vancouver were combined sewers. While the first capital costs involved were undoubtedly smaller than would have been under the separate system, the Greater Vancouver Sewerage and Drainage District—the successor to Vancouver and Districts Joint Sewerage and Drainage Board since 1956—would not now be faced with treating much larger quantities of highly diluted combined sewage had Mr. Lea's farsighted recommendations been followed.

City of Vancouver Sewerage

While Vancouver and Districts Joint Sewerage and Drainage Board built and operated trunk sewers, intercepting sewers and outfalls servicing drainage areas in excess of 400 acres, the City of Vancouver in general constructed trunks servicing areas of less than 400 acres and all of the lateral sewers within the City. Today the City is about 85% sewered.[5]

Of the other organized communities in the area the following is the approximate provision for sewerage in each as at this date.

In the Municipality of Burnaby sewerage coverage is about 25% complete;

In the City of New Westminster sewerage coverage is about 80% complete;

In the City of North Vancouver sewerage coverage is about 30% complete.

District of North Vancouver, Richmond, Coquitlam, Port Coquitlam, Delta, Surrey, Chilliwack and several of the small communities in the Fraser Valley have each made a start

2. Water Quality in the Fraser-Thompson River System of British Columbia. B.C. Research Council Report—1952.

3. Greater Vancouver Water and Sewer District Report of Commissioner Berry, 1959.

4. Burrard Peninsula Joint Sewerage Scheme—R. S. Lea, 1913.

5. The 400 acre minimum to drainage areas administered by Vancouver and Districts Joint Sewerage and Drainage Board was not fixed by the Statute, but by mutual acceptance between the Board and the City of Vancouver and other member municipalities.

on the construction of central collecting systems. Where no such provision has been made the population depends on septic tanks for its waste disposal. In some areas these work well for a few years. In other areas due to conditions of soil and ground water level these do not work effectively.

The Rawn Report and Master Plan 1953 and the Reconstitution of the Vancouver and Districts Joint Sewerage and Drainage Board[6]

Following the Second World War the metropolitan area of the Lower Mainland experienced the same rapid expansion that had been experienced by urban centres all across North America. This rapid expansion of both industry and population quickly rendered the existing sewerage and drainage facilities inadequate. By 1949 pollution of shore and shore waters in the area, as already pointed out, was becoming evident and the likelihood of continued population growth indicated very forcibly the possibility of greater and eventually intolerable pollution.

6. Sewerage and Drainage of Greater Vancouver Area, British Columbia, Sept. 1953, Gilman Hyde, Rawn and Oliver.

As a consequence the Vancouver and Districts Joint Sewerage and Drainage Board appointed an Engineering Board of Consultants under the Chairmanship of Mr. A. M. Rawn, at that time Chief Engineer and General Manager of County Sanitation Districts of Los Angeles County and later Chairman of the State Pollution Control Board of California. This Board was instructed to "review the system of trunk sewers, interceptors and sewage disposal in and around Burrard Peninsula and to submit a plan and report with recommendations and advice, indicating the steps that should be taken and their probable sequence to provide completely for the collection and disposal of the surface waters and sewage and the type of treatment processes that may be necessary to ensure the protection of bathing beaches and sanitarily acceptable conditions in the Sewerage District and in the surrounding rivers and sea waters.[7] Hope was expressed "that all the municipalities adjacent to the waters both north and south of the Burrard Peninsula from Pitt River to the Strait of Georgia will become interested to the end that sewerage facilities for the whole area may be logically planned in advance of its growing requirements".[8]

The investigations and studies carried out by the Consulting Board were comprehensive and complete. They included the physical, social and economic conditions of the five cities, five municipalities and three unorganized areas in the Lower Mainland and north of the Fraser River to be served with sewerage and drainage. A comprehensive survey of the tidal pattern in the estuary of the Fraser River, the Strait of Georgia, English Bay and Burrard Inlet covering one whole year of tidal and climatic conditions was carried out by experienced teams and the results evaluated by the Pacific Oceanographic Group of the Fisheries Research Board. Assistance was given by the Hydrographic Service of Canada, The Oceanographic Institute of the University of British Columbia and by the National Research Council.

The evaluation of the mass of data accummulated as to the current pattern, density and oxidizing capacity of the receiving waters indicated the appropriateness and feasibility of the points of discharge chosen and the nature of treatment works required.

In its letter of transmittal the Board of Engineers summarised its findings in these terms:

"Full information concerning the investigation is presented in the report. An analysis has been made of all sewerage projects considered feasible and each such project has been evaluated in terms of both general suitability and total cost. Methods of storm water drainage have been studied and costs approximated for providing the minimum degree of service commensurate with protection from flooding due to storm waters.

"The sewerage projects found to be the most economical and satisfactory involved the conveyance of sewage for final disposal to eight locations. Of these, five are tributary to the Fraser River, two to Burrard Inlet and one to the Strait of Georgia. At all but two of these locations conditions are such that sewage can be discharged to the receiving waters without treatment. At these two locations, treatment of sewage will be required. A treatment plant would be constructed on Iona Island to treat the sewage of the western portion of Burrard Peninsula and of Sea Island prior to discharge to Strait of Georgia and a treatment plant would be constructed adjacent to First Narrows to treat the major portion of the sewage produced in the North Shore section before discharge to Burrard Inlet.

"A joint agency similar to the Vancouver and Districts Joint Sewerage and Drainage Board should be formed within the Greater Vancouver area to finance, construct and operate the facilities recommended in this report. The fairest and most equitable distribution of costs will be achieved if each of the political entities within the area assume a proportion of the total annual cost of each project."[9]

The reception of the municipalities when the report was presented in

Fig. 1. Lower Mainland Communities of British Columbia.

7. and 8. See Page 8. Sewerage and Drainage of Greater Vancouver Area, 1953. Gilman Hyde, Rawn and Oliver.

9. See Letter of Transmittal — Sewerage and Drainage of Greater Vancouver, 1953 Gilman Hyde, Rawn and Oliver.

September 1953 was mixed. Only those municipal members of the then existing Vancouver and Districts Joint Sewerage and Drainage Board accepted the invitation by the Provincial Government to accept membership in a newly constituted corporation others preferring "to go it alone". (New Westminster asked to be excluded although a member of the former Board). It was not until April 1956 that the new corporation under the title of Greater Vancouver Sewerage and Drainage District was constituted by Provincial Statute. Its members were Vancouver, Burnaby, and University Lands. Within the subsequent two years however, three other municipalities saw the advantages of membership and petitioned the Executive Council of the Province to include them in the Corporation. Those added were the Municipality of Coquitlam, the Municipality of West Vancouver and the City of Port Moody. Their inclusion was accomplished by Order-in-Council of the Provincial Executive.

It is fair to state that the reluctance of some of the other municipalities situated in the Lower Mainland to throw in their lot with the new Corporation was not one of dislike of an ad hoc form of corporation to carry out the functions of sewage and drainage disposal, rather it was one of dislike for the proposal as recommended by the Board of Engineers that all members share in a proportion of the total annual cost of each project. The indeterminate costs involved in this formula due to timing, future costs of facilities and other factors, without a doubt deterred them from accepting membership.

As it turned out the legislation constituting the new Sewerage District as finally passed removed what was considered this objectionable provision of the Bill. The annual fixed charges and operating costs of all facilities constructed by the Board are charged only to the member or members who receive benefit from the facility. Where a facility is shared by two or more members the fixed charges and operating costs are shared on a basis of the land and improvement assessments situated within the drainage area served by that facility.

In the four years since re-constitution of the Sewerage District a number of sewers have been built and are in use by the members. The sewage plant on the North Shore—to serve West Vancouver only—has been designed and is under construction. The completion date is programed for spring of 1961. The Iona Island plant has been designed and tenders for it will be called before the mid-year 1960.

The initial construction of the Iona Island primary treatment plant is designed to serve 320,000 population, with an ultimate of 640,000.[10] It is designed for an average dry weather flow of 65 c.f.s.—ultimate 130 c.f.s. The interceptor which transports sewage through a tunnel from the north side of Burrard Peninsula to the north bank of the Fraser River opposite Iona Island, is about three miles long and has a capacity of 400 c.f.s. peak storm flow. The construction for this tunnel was commenced in January 1960 and will be completed in about two years. The total cost of Iona plant including the Highbury intercepting tunnel, crossing of the North Arm of the Fraser River, the effluent channel and dyke across Sturgeon Bank and other appurtenances carries a preliminary estimate of $17 million.

Its completion in 1962 and the later construction of ancillary interceptors, will remove discharges of crude sewage into the south side of English Bay except for an average of one storm overflow of dilute sewage per recreational season from the short outfalls and for an average of three storm overflows per season from the Discovery Street Outfall. The construction of this facility will improve very materially the sanitary conditions of the shores and beaches in this area.

Existing Legislation for Control of Water Pollution in B.C.

There is much legislation on the Federal, Provincial and Municipal statute books to control pollution of rivers, streams and tidal waters of British Columbia. In his review of Pollution Control legislation in British Columbia, Mr. R. Bowering, Director —Division of Public Health Engineering, Department of Health and Welfare, Province of British Columbia, points out that in the Health Act of British Columbia there has been legislation for the control of pollution since the early 1870's and also that the Federal Fisheries Act—with amending Orders-in-Council, has been in existence for many years.[11] He points out however, that all legislation in respect of pollution has over the years been enacted giving various government departments or agencies authority to enforce pollution control measures in order to achieve definite objectives inherent in their own function and responsibility. The Health Act in this regard has as its objective prevention of unsanitary and unsightly nuisances and the protection of the public health. The Fisheries Act has as its objective the prevention of pollution which would result in harmful conditions to the migration, propagation and conservation of valuable commercial and sports fish resources of the lakes, streams and salt waters.

This weakness in legislative control of pollution, however, has to a large extent been rectified, for on 1st of April, 1956 a Pollution-control Board was constituted with wide powers and duties. This Act at the present only applies to the Lower Mainland communities and adjacent waters and its provisions also are not deemed contrary to the Provincial Health Act, the Municipal Act or the Water Act but an "extension of such Acts for the public interest".

Table I indicates the various government authorities having control over pollution in British Columbia.

The hazards of public health that may be caused by pollution and against which the Health Act has for many years waged a continuous battle against increasing odds are:

1. Pollution of domestic water supplies with sewage;

2. Pollution of domestic water supplies by industrial wastes charged with materials dangerous to human beings;

3. Pollution of shellfish growing areas by domestic or industrial wastes;

4. Contamination of bathing beaches by sewage discharges;

5. Contamination of agricultural products by irrigation of crop with contaminated water or by treatment of soil with human excreta—untreated or partly treated.

Despite the overall provisions of the newly constituted Pollution-control Board, the Department of Health still maintains strict control over public water supplies by making it mandatory for municipalities and private developers to submit plans for approval before development is commenced. Such approval is supplemented by inspection and laboratory testing of public water supply systems for sanitary hazards.

All plans and specifications of public sewerage systems must be submitted to the Minister of Health before construction and, where money by-laws are required, submitted to electors for approval. The certificate of approval must be issued by the Minister of Health before submission.

10. Sewerage and Drainage of Greater Vancouver Area, B.C. Gilman Hyde, Rawn and Oliver.

11. Proceedings of 6th B.C. Resources Conference — 1953 "Pollution Control in B.C. Today" by R. Bowering, Director, Div. of Public Health Engineering, Dept. of Health and Welfare.

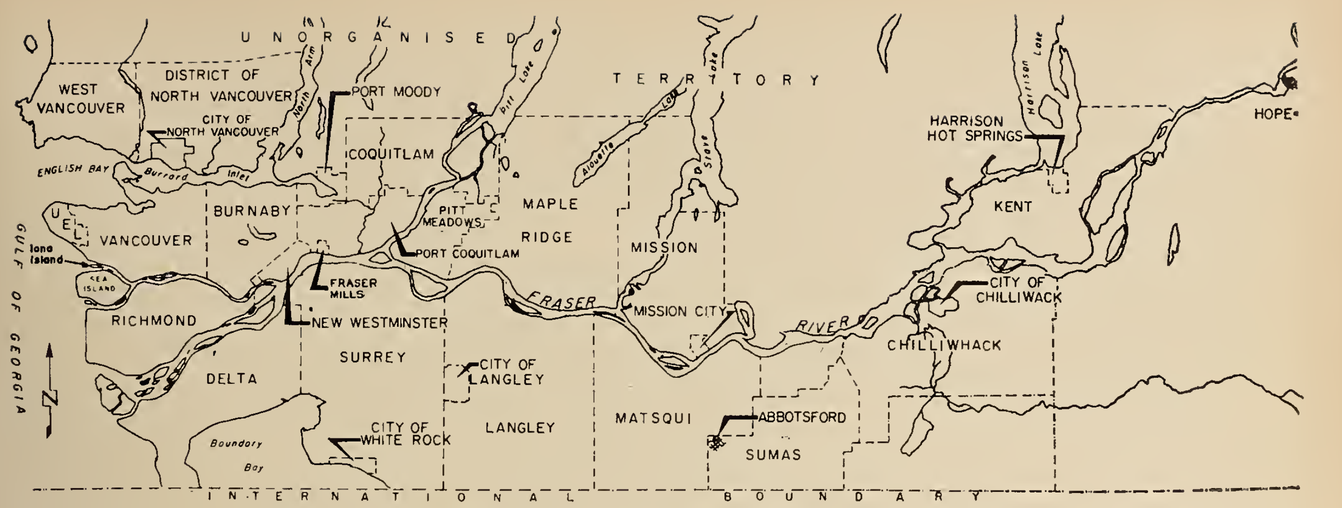


Fig. 2. Lower Mainland Communities of British Columbia, West of Pitt River.

Probably about a half of the population of the Province is served by public sewerage systems. In the Lower Mainland area this percentage is somewhat higher. However, most of the sewage to date is not treated. Table II indicates those municipalities and communities in the Lower Mainland area which are served by some degree of treatment.

As the population growth and concentrations of population have increased, the hazards have likewise increased. Within the next several years a number of communities will be required to build treatment plants. As has been mentioned elsewhere, two treatment plants serving initially over 350,000 are under construction and will be completed within the next two or three years.

In several areas in the Province sewage disposal with resultant pollution has led to abandonment of bathing beaches in order to protect public health. In 1958 the beaches of Vancouver City were "posted" by the Park Board, under whose jurisdiction they fall, on the advice of the local health authorities that the quality of the water offshore had deteriorated below sanitarily tolerable limits. Greater Vancouver Sewerage and Drainage District installed a barminutor and a chlorinator on the Discovery Street Outfall and with a contact time of from 15 to 20 minutes brought the bacterial quality of the littoral waters again to tolerable limits set by the Provincial Authorities for bathing waters.

The other half of the population of the Province not served by public sewerage systems is served by septic tanks or in remote areas by privies. These are controlled by local Boards of Health and by the Provincial Department of Health and Welfare.

The Department of Health is instrumental, where feasible, in encouraging the setting up of watershed areas by local water or health authorities. The constitution of such areas permits very close control of catchment areas by virtue of "Watershed Regulations" promulgated by the Provincial Department of Health and Welfare. Such regulations prohibit access to watersheds except for specific reasons, require medical testing of all persons entering the catchment area and generally require extraordinary standards of sanitation.

The Department maintains laboratories in Vancouver and several smaller units in other parts of the Province where sampling and testing of local water supplies are carried out.

In summary therefore, over the years the Department of Health has been effective in controlling communicable diseases which may be caused by pollution. Since World War II the rapid expansion of population has materially increased the Department's problems but it has carried out an energetic program of health education which has resulted in the gradual acceptance of the organized communities of the urgency for adequate and modern sewage disposal facilities.

Legislation Under the Fisheries Act

The Federal Fisheries Act was enacted to protect both commercial and sport fishing in Canada. In British Columbia the Federal Department of Fisheries is responsible for protection and conservation of marine and anadromous fishes.

The Fish and Game Branch of the recently constituted B.C. Department of Recreation and Conservation (formerly B.C. Game Commission), is responsible for the conservation of the nontidal sport fisheries. The Fisheries Branch of the Department of Recreation and Conservation (formerly the Provincial Fisheries Department), regulates nontidal fisheries and marine shell fisheries.

The Fisheries Act provides that it is unlawful to pollute water with materials that are deleterious to fish.[13] In this regard the Fisheries agencies in British Columbia have special regard for pollution due to:

1. Organic effluents in quantities which in the decomposing processes remove sufficient oxygen from the water below the level at which fish and aquatic life can survive:

2. Industrial wastes containing materials which themselves are lethal to fish or aquatic life on which fish feed;

3. Certain substances cast off from industrial processes such as mining and smelting wastes, sawdust, canning discharges, pulp mill liquors or oil wastes. These can be frequently lethal to fish, or may silt up the streams so as to prevent migration of fish, spawning processes or growth of food.

Water Act

Under the Water Act the Comptroller of Water Rights may restrain a water licensee from polluting the stream or lake under licence to him, where use by the licensee is detrimental to other licensees on the stream or to the public interest. While this provision is not often used it can be invoked when and where pollution conditions have reached an impasse.

Pollution-control Board—2nd March, 1956

From the above remarks relative to pollution control in British Columbia it will be seen that legislation has to a point been quite effective in controlling pollution where it ran

13. The Fisheries Act (Federal)

counter to the public interest in certain cases. Prior to 1956 there was no agency to deal with the overall pollution problem as such.

Officials and commercial agencies for a long time felt that some such agency was badly needed. Pollution of lakes, streams and tidal waters for the most part was still in the preventive stage and if effective measures were promulgated before the problem became a major one in the Province much of the natural-resource potential of the waters of the Province would be prevented from becoming degraded if not completely lost.

Recognizing the need for such an agency the Provincial Legislature enacted in March, 1956 the Pollution-control Act concurrent with the reconstitution of the Vancouver and Districts Joint Sewerage and Drainage Board. This Act set up a Pollution-control Board with wide powers and duties relative to pollution of the waters of the Lower Mainland.[14]

Its preamble reads as follows: "Whereas it is deemed in the public interest to maintain and ensure the purity of all waters of the Province consistent with public health and the public enjoyment thereof, the propagation and protection of wild life, birds, game and other aquatic life and the industrial development of the Province: and whereas it is deemed expedient to require the use of all known available and reasonable methods of industries and others to prevent and control the pollution of the waters of the Province. Now therefore, Her Majesty . . ."

Some of the provisions of the Act are:

1. It defines pollution as "anything done, or any result or condition existing, created, or likely to be created, affecting land or water which, in the opinion of the Board is detrimental to health, sanitation, or the public interest.";

2. *Section 3(1)*. There shall be a board to be known as the "Pollution-control Board" which shall consist of a chairman and such other members as the Lieutenant-governor in Council may from time to time determine;

Section 3(2). The members shall be appointed by the Lieutenant-Governor in Council for such term or terms as the Lieutenant-Governor in Council may determine;

Section 3(3). The Board may determine its own procedure and may elect an acting chairman in the absence of the chairman.

The Board shall have the following powers and duties: (Section 4)

(a) To determine what qualities and properties of water shall constitute a polluted condition;

(b) To prescribe standards regarding the quality and character of the effluent which may be discharged into any waters within the area or areas under the jurisdiction of the Board;

(c) To conduct tests and surveys to determine the extent of pollution of any waters within the area or areas under the jurisdiction of the Board;

(d) To examine all existing or proposed means for the disposal of sewage or other waste materials, or both, and to approve the plans and specifications for such works as are deemed necessary to prevent pollution of the waters of the area or areas;

(e) To notify all persons who discharge effluent into the said waters when the effluent fails to meet the desired standards;

(f) To order any person after six months from date of notification or such longer period as may be determined by the Board to increase the degree of treatment of the effluent or to alter the manner or point of discharge of the effluent being discharged by such person to bring the effluent up to the prescribed standards;

(g) To order any person who fails to comply with an order issued under Clause (f) to cease discharging effluent into any waters in the area as and from a day and time specified in the order.

The Act provides penalties for contravention of the Act or any order of the Board (Section 5). The Act provides also an appeal from any order, determination, or decision of the Board, shall lie to the Lieutenant-Governor in Council, whose decision thereon shall be final and binding. Such appeal must be made within 30 days from the date of any order, determination or decision of the Board.

Section 7 provides—no person shall discharge sewage or other waste materials into the waters of the area or areas under the jurisdiction of the Board without the permission of the Board. Such permission may be in the form of a permit, which may prescribe the degree of treatment of the effluent as well as the location of the point of discharge into the waters of the area and the manner of the discharge as a condition of the permission.

Section 8—provides there may be made available to the Board by the Health Branch of the Department of Health and Welfare such engineers, inspectors, technicians, officers, clerks and employees as are necessary for the administration of this Act.

Section 9 authorizes that members of the Board shall be paid such remuneration as may be fixed by the Lieutenant-Governor in Council, and such actual expenses as may be incurred by them in the discharge of their duties.

Section 10—any moneys required for the administration of this Act or for carrying out the provisions of this Act shall, in the absence of any vote of the Legislative Assembly available therefor, be paid out of the Consolidated Revenue Fund.

Section 11 provides that the Minister of Municipal Affairs shall be charged with the administration of this Act.

Section 12 provides that—notwithstanding the provisions of any other Act, the provisions of this Act shall apply to:

14. Pollution-control Act — Chapter 36 — 1956

TABLE I

Government Authorities Having Control over Pollution in British Columbia.

1.	Federal	Dept. of Fisheries	"Fisheries Act"
		Dept. of Resources and Development	"Migratory Birds Regulation Act"
		National Harbours Board	"National Harbours Bd. by-laws"
		Dept. of Transport	"Navigable Waters Protection Act" "Canada Shipping Act"
		Dept. of Health and Welfare	Advisory to International Joint Commission relative to pollution of boundary streams.
		Dept. of Public Works	"Navigable Waters Protection Act"
		Local Port Authorities—Dept. of Transport	"Navigable Waters Protection Act"
2.	Provincial	Health Branch—Dept. of Health and Welfare	"Health Act" of B.C. Sanitary regulations under Health Act
		Water Rights Branch—Dept. of Lands and Forests	"Water Act"
		Dept. of Municipal Affairs	"Pollution-control Act" 1956
		Dept. of Recreation and Conservation	"Dept. of Recreation and Conservation Act, Ch. 53-1957"
		(a) Provincial Parks Branch	Park regulations
		(b) Fisheries Branch	Federal legislation regarding fish—"Fisheries Act"
		(c) Fish and Game Branch	Federal legislation regarding fish—"Fisheries Act" "Migratory Birds Regulation Act"
3.	Municipal	Local Boards of Health	"Health Act" of B.C. "Sanitary Regulations" under Health Act "Municipal Act—1957" (Sections 531, 634 and 635)

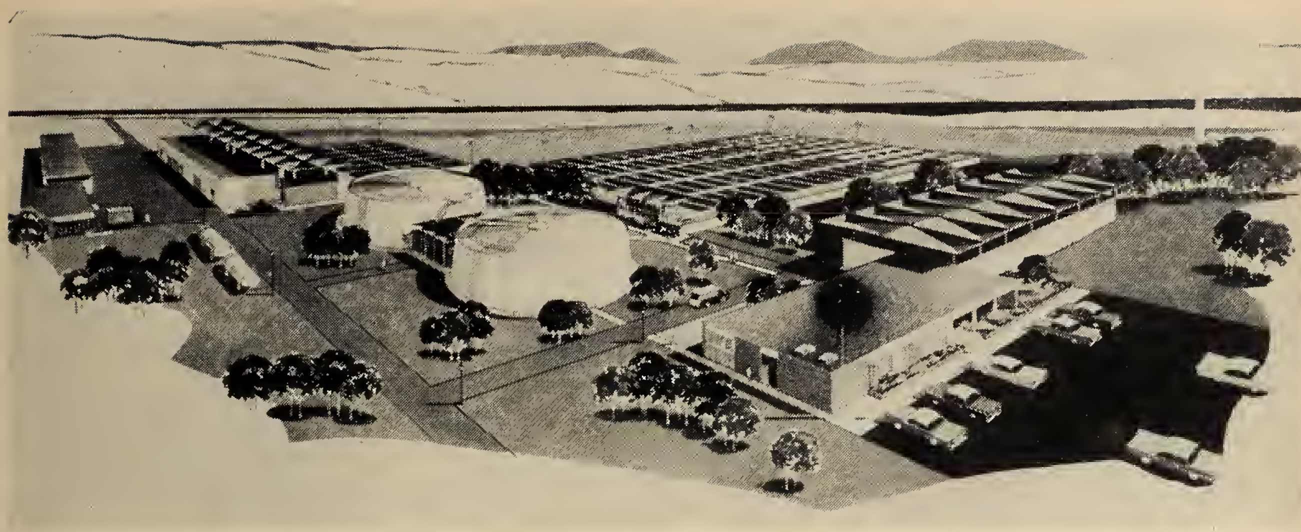


Fig. 3. Iona Island Sewage Treatment Plant.

All the areas of land, contained within the boundaries of a municipality draining by natural or artificial means, into the Fraser River or its tributaries from the Village of Hope to the Strait of Georgia or into Boundary Bay or into the area of the Strait of Georgia contained within a line drawn from the International Boundary-line at longitude 123°-15′ to Halfmoon Bay or into Burrard Inlet.

Any area designated by Order of the Lieutenant-Governor in Council.

Section 13—The provisions of this Act shall not be deemed contrary to the provisions of the Health Act, the Municipal Act or the Water Act but shall be considered an extension of such Acts for the public interest.

Section 14—For the purpose of carrying into effect the provisions of this Act according to its true intent or supplying any deficiency therein the Lieutenant-Governor in Council may make such regulations not inconsistent with the spirit of this Act as are deemed necessary or advisable.

A glance at a map will show that the area covered by this Act is approximately the same area covered by the discussions of this paper. Section 12(b) provides that the Act can readily be extended to other areas of the Province by Order-in-Council. When the Act was passed it was indicated that data and experience gained in administration of the Act in the limited area defined would at a later date make appropriate enlargements relatively simple.

The Board, consisting of seven members, was constituted by Order-in-Council after the Act was promulgated. The Executive Council appointed the Deputy Minister of Municipal Affairs as Chairman and three government officials, namely the Comptroller of Water Rights, the Deputy Minister of Health and Welfare and an official of the Department of Fisheries.[15]

Three members were appointed pursuant to recommendation made by three groups of municipalities. The municipalities north of Burrard Inlet, three in number, recommended one member. The Burrard Inlet municipalities, eight in number, recommended one member. The Fraser-Delta municipalities, three in number, appointed one member. The original seven members still serve.

In the four years since the Board was constituted it has dealt with approximately 40 applications. Applicants for permits are required to file preliminary plans detailing the nature of effluent to be discharged into the receiving waters, the point of discharge, area of land and population to be served, type of treatment proposed and other relevant information. Applicants must display in the local newspapers and in the B.C. Gazette a copy of their application and in addition "post" the application at the point of discharge.

Application for Authority to Build and Operate a Primary Sewage Treatment Plant on Iona Island

Perhaps the most important application dealt with by the Board was that of Greater Vancouver Sewerage and Drainage District for authority to build the primary treatment plant on Iona Island to eventually service all of the University Lands, the City of Vancouver and westerly portion of Burnaby.

This plant, to be constructed on Iona Island (a sand bar of 180 acres in area, in the North Arm of the Fraser River) is planned as a high-rate primary plant with effluent discharge to the tidal waters of the Strait of Georgia through an effluent channel. As reported, the ultimate capacity of the plant is to serve 640,000 population with an initial population of 320,000. The effluent channel will traverse Sturgeon Bank, a tidal flat, for about four miles to deep water. Parallel and north of this channel will be constructed a dyke to deter the highly diluted primary effluent from reaching the southerly side of the island and its westward extension.

Strong disapproval of the application was made by the Municipality of Richmond, in which municipality the plant is to be situated. The Pollution-control Board in due course held a public hearing. It granted the application, making at the same time specific requirements as to the bacteriological conditions of the receiving waters after the plant was placed in operation.[16]

In general these criteria are:

1. The quality and character of the water south of the proposed dyke shall be determined by systematic sampling. The median M.P.N. (most probable number) of coliforms in that water shall not be greater than 35,000 per 100 ml. for any year, nor greater than 10,000 for any five month period from May to September inclusive (the recreational months). Dissolved oxygen shall never be less than 5 p.p.m. If any of these criteria are not met the Greater Vancouver Sewerage and Drainage District shall, without undue delay, take whatever steps are necessary to improve the quality of the water at least suffi-

15. This Department now included in the Department of Recreation and Conservation as "Fisheries Branch".

16. Order No. 23 of Pollution-control Board — April 2nd, 1958

ciently to meet the criteria demanded. Sampling points, methods of sampling, at what stages of tide they are to be taken and other directions were specified.

2. The quality of the water at Iona Beach as determined by systematic sampling shall conform to the following: If the median M.P.N. of coliforms per 100 ml. exceeds 240 in any period between May and September inclusive, the Greater Vancouver Sewerage and Drainage District shall, if requested by the Pollution-control Board, improve by whatever means may be required, the quality of the water at least sufficiently to meet the prescribed criteria.

A comparison of these criteria with those used on the Pacific Coast and other points in North America will indicate they are as stringent as any. The Sewerage District proposes to chlorinate effluent at the Iona plant both before and after sedimentation, during the recreational season if necessary, to attain these criteria.

Appeal by Municipality of Richmond Against Order No. 23

Under Section 6 the Municipality of Richmond appealed the decision of the Pollution-control Board. The Provincial Cabinet heard the appeal, confirmed the decision of the Pollution-control Board but added additional provisos for measures which the applicant must carry out. In its amending order it set the following criteria for condition of water off bathing beaches in the English Bay area, these beaches on the northerly side of English Bay being in an area quite remote from the Iona Plant.[17] These additional provisions are:

1. The Iona plant is to be adequately designed and appropriately landscaped to prevent impairment of the recreational amenities of Iona Island and beach.

2. There must be no public nuisance by offensive odors from plant and works.

3. That conditions, as indicated above by Pollution-control Board Order, apply to beaches at English Bay, Third Beach, Second Beach, English Bay Bathing Beach, Kitsilano Beach, Jericho Beach, Locarno Beach and Spanish Banks.

4. That Greater Vancouver Sewerage and Drainage District indemnify the Corporation of Richmond for impairment of the recreational amenities arising out of breach of the imposed conditions and enter into a written agreement with the Corporation therefor. (This was done in due course by filing a document in a form of guarantee as required by the Order-in-Council).

The above is recited in some detail in order to indicate to what extent the Provincial Government and its instrumentalities are prepared to go in order to effectively control pollution. On the basis that "an ounce of prevention is worth a pound of cure" their intent in this regard is to be highly commended.

Watershed Control

No paper on pollution control in the Lower Mainland communities would be complete without a reference to the matter of watershed management control. Reference has already been made to the encouragement, at the Provincial level, of the setting up by local Boards of Health or Water Authority of closed watershed areas with strict regulations of access and imposition of rigid control where access must be permitted even on a limited basis.

A number of the larger communities in the Lower Mainland area under review and two on Vancouver Island (Victoria and Nanaimo) have acquired by outright ownership or lease the catchment areas of their watersheds, thereby preventing housing, industrial development, logging (in most cases) and uncontrolled hiking, skiing and fishing.

Probably the most comprehensive example of this protection is that of the catchment areas of Greater Vancouver Water District. The Greater Vancouver Water District is a metropolitan district composed of four cities, ten municipalities and two unorganized areas serving a population of about 750,000. Its three catchment areas total 226 sq. miles situated in the rough mountainous country north and east of Burrard Inlet.

By farsighted action taken soon after the Water District's inception in 1926, about 80% of the land is held for waterworks purposes by a 999 year lease of Crown lands. The other 20% is virtually all held in fee simple, the land having been purchased as opportunity offered. The catchment areas are reserved against public access under the watershed regulations. They are declared also to be reserved from being entered on, prospected, mined, located, recorded or acquired

17. Order-in-Council 2167 of the Executive Council of the Province of British Columbia. September 22nd, 1958.

TABLE II

	Estimated Population as of Dec. 31, 1959	Population Served by Treatment
Abbotsford, Village of	830	
*Burnaby, District of	96,000	1,050 (8)
Chilliwack, City of	7,165	
Chilliwack, District of	17,000	2,500 (1)
Coquitlam, District of	30,000	550 (5) 50 (6)
Connaught Heights, D.L. 172, Unorganized	1,450	
Delta, District of	12,000	
Fraser Mills, Corp. of	200	
Harrison Hot Springs, Village of	487	
Hope, Village of	2,500	
Langley, City of Langley, District of	12,281	
Maple Ridge, District of	16,750	
Matsqui, District of	11,521	
Mission, District of	4,711	
Mission City, Town of	3,300	
New Westminster, City of	35,000	
North Vancouver, City of	23,200	
North Vancouver, District of	32,490	1,200 (2)
Pitt Meadows, District of	1,825	
Port Coquitlam, City of	5,000	
Port Moody, City of	4,200	
Richmond, District of	36,400	3,000 (7)
Sumas, District of	4,700	
Surrey, District of	55,000	
*Vancouver, City of	407,000	
.West Vancouver, District of	22,100	500 (4)
White Rock, City of	6,200	5,500 (3)
*University Endowment Lands (including U.B.C.)	4,600	
Total	853,910	
Population of Province, Dec. 31st, 1959	1,570,000	

* Vancouver, Burnaby (portion) and University Endowment Lands to be serviced by Iona Island plant—first unit 320,000 population, ultimate 640,000. First unit to be completed 1962.

. West Vancouver—Hollyburn Drainage Area—plant under construction First Narrows. First Unit 32,000 population to be completed in 1961. Ultimate 64,000.

(1) Army Camp at Sardis—Primary clarifier—chlorinated effluent discharging into Chilliwack River.

(2) West Lynn—District of North Vancouver, Dorr Oliver Duo clarigester with high rate filter.

(3) White Rock—Activated sludge plant.

(4) Horseshoe Bay—West Vancouver. Large septic tank discharging into Horseshoe Bay.

(5) Ranch Park—Coquitlam. Fairbanks Morse spiragester and chlorination.

(6) Essondale—Mental Hospital. Septic tanks serving individual buildings.

(7) Lulu Island—Richmond. Primary treatment discharging into Middle Arm of Fraser River.

(8) Oakalla Prison Farm. Inhoff tank and secondary treatment discharging into Deer Lake.

under the Mineral Act and the Placer Mining Act. The area is also set up as a reserve against trapping, hunting and fishing.

Other municipalities in the Lower Mainland which have catchment areas protected in a similar way are West Vancouver, City of North Vancouver, the City of Mission and the Elk Creek Water Company's catchment area which serves the City of Chilliwack and environs. Such rigid control gives excellent protection against ravages of forest fire in summer months with consequent loss of forest cover and the accompanying problems of rapid run-off and high turbidity. The protection of the water supply by total exclusion of the public is one of good fortune indeed. With ability to carry out this program by virtually complete ownership of the catchment areas situated so close to the center of population, advantage can be taken of economies inherent in short supply mains, no treatment of the water except chlorination and little risk of contamination by human agency. The catchment areas are covered with dense forest growth. It is quite possible in the interests of a thrifty forest that a program of selective cutting under rigid control of the cutting operations may be undertaken in the future. Much of the timber is mature, some over-mature and decadent.

A program of cutting of mature and over-mature timber would improve the forest and provide a useful income from sale of timber which should be ploughed back into improvement of the forest, the removal of snags and the provision of jeep roads for fire suppression.

Conclusion

The rapid growth of the Province since World War II has brought many problems to the Province, amongst these that of pollution of its waters. At all times a persistent follower of economic development, its presence is inevitable — perhaps in some aspects desirable, but its control within tolerable limits is and will always be difficult.

In the United States it was not until recent years that water resources appeared to be running short. Due to greatly increased population, the almost explosive increase in use of water and the gross pollution of many of its water resources, the country became alarmed and a major program of controlling the deterioration is being carried out at both the State and Federal levels.

In British Columbia we have been fortunate that the experience of other industrial countries in this regard has had its impact on our own thinking before it is too late. Our growth has been phenomenal in recent years and with this growth pollution problems have increased to a point where they are potentially becoming chronic. Due to our other urgent preoccupations the economic depression of the 1930's and the war of the 1940's set back the time when these problems might have received attention.

However the diligence, dedication and persistence of people at government, university and industrial levels has awakened the government and the people to the dangers. Public bodies too have persuaded governments that preventive measures must be undertaken. The reconstitution of the Vancouver and Districts Joint Sewerage and Drainage Board and the creation of the Pollution-control Board after some years of delay, have enabled both Authorities to carry forward their well defined programs of prevention and abatement of pollution in their respective areas.

While some of the trouble spots may not be eliminated overnight — financial and other difficulties will defer them — there is satisfaction in knowing, first of their existence and their scale of pollution, and secondly that there is a well-ordered plan for their elimination. In due course these corrective measures will be carried out. Future generations will be thankful for the diligence of the Authorities in initiating preventive measures during this decade before it is too late to effectively remedy what would develop into a catastrophic condition of environmental waters.

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STREAM POLLUTION AND ITS CONTROL IN ALBERTA

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Stream pollution studies are conducted by the Provincial Department of Public Health through the Division of Sanitary Engineering. The data obtained are used to assess the need for waste treatment and also to evaluate the efficiency of control measures. The critical period is winter when ice cover prevents reaeration and the streams are at minimum flow. This has resulted in two significant methods of approach to pollution control, viz. the amount of polluting materials which may be released to a stream is in many cases prorated to river flows and secondly, the method of control by industry includes incineration or ponding. Ponding is a suitable solution because ponded wastes may be released when higher flows and open waters are present. The great reduction between summer and winter in the capacity of a river to absorb oxygen-demanding wastes is shown. One phase is the control of odours; brief mention is made of the effect of a petroleum type odour on fish. Each river is dealt with separately; the probable minimum flows, the critical polluting materials and the existing pollution loads are discussed. The Edmonton area and the North Saskatchewan River are dealt with in detail, as this is the largest center of population and industry in the province. The effect of secondary treatment of the City of Edmonton sewage on the dissolved oxygen content of the river is shown. Similarly the reduction in phenolic and odourous materials in industrial waste is tabulated.

THE ADVERSE effects of pollution, including in extreme cases the stifling of industrial growth, are well known. Many articles and examples could be quoted to justify the maxim that water in large quantity and of good quality is a vital necessity where the growth of populations requires that the growth of industry keep pace to provide full employment and maintain a good standard of living.

It is believed that the situation in Alberta will be of interest because of several factors which are unique to the west central plains area, the most critical of which is the heavy ice cover on the streams for as long as five months of the year.

Prior to 1940 the population and industrial growth in Alberta was such that the streams in the Province were capable of handling the wastes poured into them without any evident ill effect. By 1949, conditions had changed considerably and the Department of Public Health through the Division of Sanitary Engineering began a program of stream sanitation studies. These have continued since that time and the data obtained have made it possible to fully assess the pollution load, set up a logical method of dealing with pollution and forecast for some years the waste treatment that will be necessary. General objectives have been set up for the streams in the province and it has thus been possible to work back to cities and industries and allocate to each an allowable pollution load. As an example, the allowable pollution load for the North Saskatchewan River at various levels of flow was determined and this load distributed among municipalities and industries as pounds per day of B.O.D.. and phenols. Similarly limits were set for other pollutants.

In presenting the data in regard to this province it is intended first to point out those factors which although they may not be unique, are factors which are common to the streams in the Province.

Flows — The major source of water in the rivers on the prairies is the mountain areas to the west. The total preciptation in Alberta averages about 15 in. per yr. but there is a large loss through evaporation and transpiration, so that for streams in the Province which do not rise in the mountains the average runoff can be as low as 20 acre ft. per sq. mile or about one fortieth of the average precipitation. In the area to the south of the Athabasca River there are no large lakes; those lakes which exist are small if one considers the amount of storage they afford in terms of some daily average flows in a stream. These lakes and the streams flowing from them are now in equilibrium and to augment the low flows it would be necessary to create storage.

The mountain areas receive more snowfall than the prairie areas and it is from the mountain snow melt that the major flows occur. The peak flows therefore occur in the summer months from May to September and usually during the period of hot weather in June and July. Conversely the low flows occur during the colder months when there is no snow melt and the water comes from mountain lakes and seepages of ground water.

An interesting river in this regard

is the North Saskatchewan. From Edmonton to Prince Albert (a distance of about 350 miles) the flow is substantially constant; the river neither gains nor loses water in this distance in the winter months. In the Red Deer River the flow decreases during the winter months between the gauging station at Red Deer and the downstream one at Empress.

The maximum flows are not critical for pollution but in some cases the high summer flows are used to dispose of strong wastes which could not be released during the winter months. Table 1 illustrates the variations in the flow in the main rivers for the year 1954-55 which is considered to be an average year.

Since pollution is a matter of degree, one of the key factors in control is a study of river flows, particularly the probable minimum flows. Since the critical months occur in the winter period, the data for plotting were compiled by taking from the Dominion Hydrographic records, the lowest monthly average flows in each of the winters on record. The simplest approach was used and the data were plotted on arithmetic probability paper on which most of the data provided a line of reasonable fit, although some rivers showed well defined breaks at the median values. In order to show most of the rivers on one plot the ordinate "R" was taken as the ratio of the flow for the point of computation, to the average flow for the low winter months on record, in addition; only the lower portion of the plot is shown. The probable low winter flow for any given percentage of time may be found by multiplying the ordinate "R" by the average for that stream shown in Table 2.

For example the lowest average monthly flow which might be expected in the North Saskatchewan once in ten years would be found in the following manner: at 10% of time (once in ten years) the value of "R" is 0.72. The average of the minimum monthly average flows on record is 1,080 c.f.s. (Table 2, Col. 3). The expected low flow would be 780 c.f.s., i.e. 0.72 x 1,080.

In Alberta the probable minimum low flow which is expected to occur not more than once in ten years is used as a basis of computations for determining allowable pollution.

Ice Cover — Ice cover exists on the rivers for a period of several months of the year, during the period of low flows. While there are open points in the upper reaches of the rivers in the foothills, the longer stretches through the prairies are continuously covered with ice. In a normal winter this may reach a thickneess of over 3 ft. It is interesting to note that river ice is often of greater thickness than is the ice on lakes in the same area. The dissolved oxyxgen in the stretches which are not affected by pollution is very close to the saturation value, varying from 10 to about 12 p.p.m. In the freeze up period, which may be due to a cold spell of several days at very low temperatures, a phenomenon occurs as follows: the dissolved oxygen in the river is increased sometimes above the saturation point and the flow is reduced considerably. It is not uncommon to find that for a week or so the flows in the month of November or December will fall to a very low figure in comparison to the flow immediately preceding and following that period. Fig. 1, a hydrograph of the North Saskatchewan River for the period, September to May for the years 1954-55 and 1955-56, illustrates the seasonal variations of the rivers (note the low flows in November 1955).

Ice cover has a serious effect on the capacity of a river to absorb wastes. This is because the ice prevents reaeration and the accompanying resupply of oxygen. Fig 2 illustrates this point. Lines 1, 2, 3 and 4 are based on normal equations used for computing oxygen balance. The population equivalent in terms of Biochemical Oxygen Demand (B.O.D.) was computed on a basis of 0.17 lb. of 5 day 20° C. B.O.D. per capita per day. (Ref. 1 Page 175—Phelps Stream Sanitation.) The values of the constants used in this plot are given in Table 3.

TABLE 3

Values of Constants used in Fig. 2

Curve	*Temperature*	"k_1"	"k_2"	*tc (days)*
1	20°C	0.1	0.5	1.75
2	20°C	0.1	0.4	2.00
3	20°C	0.1	0.3	2.40
4	20°C	0.1	0.2	3.00

k_1 = rate constant for B.O.D. reaction
k_2 = reaeration constant
tc = critical time in days.

Line 5 is plotted on the basis that the ultimate first stage B.O.D. under ice cover in a river is approximately equal to the 5 day 20°C. B.O.D. The reduction in dissolved oxygen in the river approaches 90% of the B.O.D. and appears to be satisfied in about ten days. Fig. 2 is drawn for point source of B.O.D. Multiple sources would give higher allowable total population equivalents except for the

TABLE 1

Flow Volumes in Alberta Rivers from October 1954 to September 1955

River	*Location of Gauging Station*	*Max. mean month c.f.s.*	*Min. mean month c.f.s.*	*Mean for the year c.f.s.*	*Flow Ratios max. min.*	*mean min.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Peace	Taylor, B.C.	192,000	9,650	53,400	20	5.5
Athabasca	Athabasca	45,630	2,734	16,560	17	6.1
North Saskatchewan	Edmonton	19,580	1,602	7,814	12	4.9
Red Deer	Red Deer	5,824	402	2,301	14	5.7
Bow	Calgary	6,388	2,231	3,419	2.9	1.5
Elbow	Calgary	878	125	357	7	2.8
Oldman	Lethbridge	12,200	885	3,300	14	3.7
South Saskatchewan	Medicine Hat	21,740	2,669	8,221	8.1	3.0
TOTALS		304,240	20,298	95,372	15.0	4.71

TABLE 2

Averages of the Minimum Monthly—Average Flows

River	*Gauging Point*	*Average of the min. monthly average flow for years of record —c.f.s.*	*Min. average monthly flow on record —c.f.s.*	*Years of record*
(1)	(2)	(3)	(4)	(5)
Athabasca	Entrance	907	410	25
Athabasca	Athabasca	2,861	1,750	17
Battle	Ponoka	16	0.1	16
Bow River	Calgary	1,110	668	45
Lesser Slave	Slave Lake	801	455	16
North Saskatchewan	Edmonton	1,080	578	48
Oldman	Lethbridge	581	211	36
Peace River	Peace River	9,870	7,030	16
Red Deer	Red Deer	277	96	44
Red Deer	Empress	245	35	24
South Saskatchewan	Medicine Hat	1,953	638	42

case of ice cover (Line 5) where population equivalents are directly additive.

In addition to the reduced reaeration, the low temperature under the ice lowers the general biological activity of the stream thus permitting contaminants to travel much further.

Turbidity — The turbidity in the rivers is high in the flood season when the snow melts and when rainfall occurs. This turbidity may be of the order of 2,000 p.p.m. or more, and at the peak periods it causes considerable trouble in the intakes for the various cities and industries taking water from streams which have this characteristic. At first hand it can be noted that a sample of water taken from the North Saskatchewan River may have as much as ⅛ in. of sediment in a sample which is taken in a bottle 10 in. tall. It is true however, that this occurs only for a short period of the year, seldom for more than a few weeks. During the winter period turbidity and colour is extremely low giving the water a clear sparkling appearance.

Spring Runoff — It may be interesting to note that spring runoff does not usually cause floods in the rivers. Floods are often evident in rural areas where low roads are flooded, but the flows in the main rivers are not exceedingly high. This may be explained on the basis that the snow melt in the mountain areas which was previously mentioned, does not occur at the same time as the snow melt on the prairies. Storm sewer design in a metropolitan area does not have to be designed for snow melt, since this takes place over several days and the resulting runoff does not approach in intensity the runoff from the conventional thunder storm.

Where the Rivers Flow—One other point which should be considered in connection with the rivers in Alberta is that all of them flow into another province or the Northwest Territories, except one river, the Milk River which flows into the United States. Saskatchewan is the only other province in Canada with this dubious distinction. This has a bearing on the allowable pollution in the rivers. If there were some streams which had ocean outfalls or emptied into very large bodies of water it would be possible to use some of these as open sewers if they were suitably located, and thus enable some industries with wastes which are difficult to treat to save some expense in their operations.

In Alberta an attempt has been made to prorate pollution loads to river flows. It is true that in some areas the laws which regulate stream

Fig. 1. Daily Discharge. For the North Saskatchewan River at Edmonton 1954-55 and 1955-56.

pollution set standards for various types of waste. This has been done because there is some uniformity in the type of waste which has to be dealt with, or the degree of pollution has been such that this was necessary. A more realistic approach, which does not in the least reduce the responsibility of an industry or a city to treat its wastes, is to set some limit to the concentration of the waste which will be permitted in the receiving stream. This last method of stream pollution control is a flexible one. It enables the control authority to set standards for plant effluents which vary with stream usage and dilution.

It has been found sufficient, in all rivers but the North Saskatchewan and the Athabasca, to specify only the general type of treatment that sewage or industrial wastes shall receive. Fig. 3, drawn for conditions of ice cover only, indicates the type of treatment required for municipal waste (sanitary sewage). The curves have been drawn for conditions of ice cover using 6 p.p.m. of dissolved oxygen (leaving 4 p.p.m.). It is assumed also that primary treatment reduces B.O.D. by 33% and secondary treatment by 90%. For any given river flow and for an equivalent population, the type of treatment required may be ascertained. The right hand scale gives the allowable B.O.D. load which varies directly with river flows.

In the case of the North Saskatchewan and in particular the Edmonton area several industries as well as the City contribute wastes to the river. It was necessary to distribute the allowable stream load to each municipality and industry. The allocation to each was made on the basis of need for disposal and the practical limit of treatment. The allowables were stated in pounds per day (phenols, B.O.D.) or in maximum concentrations in a definite volume of waste (odours). On the Athabasca a limit was set for the B.O.D. of the pulp mill effluent, in pounds per day. In each case the allocations were prorated to river flows.

In order to give a comprehensive picture of the existing state of pollution in the Province and of the various control measures being taken, the rivers in the Province will be taken in turn, beginning with the most northerly.

The Peace River

The Peace River is the largest of the rivers in the province, the average flow being 57,000 c.f.s., and the average monthly low flows in the winter being 7,000 c.f.s. At the present time there is no measurable pollution on this river. There are no industries located on the river in Alberta and the Town of Peace River is the largest centre (population 2,293). Although the situation will undoubtedly change in the future this stream is at present too far removed from the centres of population to be of aid in meeting the demands for waste dilution. There is a possibility that a power site will be located on the Peace River in B.C. If this occurs the flows in the river could be conceivably of the order of 36,000 c.f.s. at all times.

The Peace River is a tributary to the McKenzie. It flows close to but does not enter Lake Athabasca except possibly when it is at flood stage. The river is used in season for navigation purposes.

The Athabasca

The Athabasca River rises in the Jasper National Park, some of the flow beginning at the Columbia Ice Fields. The average flow is of the order of 6,600 c.f.s. and the winter flow is as low as 410 c.f.s. (Entrance). Not far from the gates of Jasper National Park is the Hinton town site and a large pulp mill. This mill has been in operation for a period of three years. The river is used as a source of water for the mill and the mill wastes flow into the river. Below this point the river courses for some 300 miles through very sparsely settled country to Smith, and then to the Town of Athabasca which uses the river as a source of raw water for the domestic water supply. Prior to reaching the Town of Athabasca the flow is augmented by the Lesser Slave River which although it is not a large river flows from Lesser Slave Lake and thus has a fairly steady winter flow which is of the order of 801 c.f.s. Below Athabasca the river flows on through the world famous tar sands at McMurray, and then on to Lake Athabasca which is in the north east corner of the Province. These waters then flow northward to the Arctic Ocean via the McKenzie River.

Since the pulp mill has been in operation numerous checks have been made to ascertain the degree of pollution in the river. The data obtained are summarized in Table 4.

There are several points which may be described in general terms. The main effect of the waste is to produce a high B.O.D. in the river, to cause considerable odour and to add to the colour of the water. These effects are more pronounced and prolonged in the winter period. In summer there are some odours arising from the river and at time there is a considerable amount of visible foam.

The condition of the river has been the subject of heated comments by some persons who have seen and used it for recreation in past years, when it was free of any pollution. This is understandable. However, where industry or large populations are centred it follows that the rivers will never be able to retain their original state of cleanliness.

The treatment provided at the mill consists of settling the cooking liquor and that part of the waste which contains the higher amount of B.O.D. and suspended solids. The total use of water at the mill is of the order of 25 m.g.d. The portion of the waste which is settled out is about 8 m.g.d. While these ponds are operating and provide the 72 hr. detention period for which they were designed, the suspended solids are reduced to about 10% of those going into the pond. There is only a slight reduction in the B.O.D. and little if any reduction of the colour and the odour of the effluent.

It is evident that this one pulp mill (450 tons per day) uses all of the available resources of the river. The odour number of the raw water in the Athabasca close to the mill at times reaches 150—this has occurred when the flow in the river was at about 1,200 c.f.s. It is felt that if the predicted 10 yr. low flow or a repetition of the low flows on record were to occur the water supply at Athabasca would be affected. Laboratory tests indicate that the removal of the odour would be difficult. In regard to the B.O.D. load from the mill, it will serve to give some measure of it to point out that it is very close to that of all of the wastes from the city of Edmonton and the surrounding industrial area.

When the mill was constructed it was realized that there would be adverse effects on the stream and a limit of B.O.D. was set so as to permit the mill an allowable load equal to one half of the dissolved oxygen in the stream at low flows.

Up to the present time the mill has not been able to meet these requirements. The problem is somewhat complicated in that the treatment of the waste is very difficult and there are few if any mills where the effluents have been successfully treated. Ponding of the effluent for a period of a few weeks in warmer climates has been successful. The cost of constructing such storage would be enormons at Hinton, and without the assurance of much benefit in the winter period.

TABLE 4

Pollution Data for the Athabasca River (Winter Values)—January 1960

Point of sampling	*B.O.D.*	*D.O.**	*Relative Color (500)***	*Odor No.*
Above Hinton................	0.15	12.0	70	0
Below Hinton (4 miles)........	5.8	10.8	115	150
Whitecourt (120 miles)........	0.75	9.1	80	16
Athabasca (420 miles).........	1.55	9.4	80	16

*An aerial reconnaissance by helicopter in January indicated that as there were several open points in the river some reaeration could take place.
**Run at a wave length of 500 mμ on a photocolorimeter.

The North Saskatchewan

The largest centre of population and major portion of the industry in the Province is located on the North Saskatchewan River at Edmonton. The population of the City and the suburbs is 320,000. The larger industries are: three oil refineries with a total capacity of about 50,000 bbl. per day, a plant which produces cellulose acetate yarns and various petrochemicals, an asphalt shingle plant and another chemicals plant. There are several other industries which are smaller or do not have liquid wastes of any consequence. These are the cement plants, the steel rolling mill, the plywood industry and a nickel refinery.

The industries mentioned are those which are located outside the City and have separate outfalls. Within the City there are a multitude of smaller industries and there are also three packing plants. These packing plants are one of the major sources of industrial waste both as to the quantity of water which they use and the quality of their effluents.

The impact of stream pollution struck the Edmonton area in 1953 when along with the already increasing B.O.D. load on the river a few more industries contributing to the waste flow were sufficient to exceed the load which the river could handle. One of the most striking effects on the river was the odour and taste present at Prince Albert in Saskatchewan and on into Manitoba. Although there were other contributing factors the main source of the odour was considered to be the primary oxidation unit at one of the chemicals plants. The plant was placed in operation in the fall of 1953 and the odour in the river became apparent at Prince Albert a few weeks after that time. In that year the only possible solution to the problem would have been to close down this plant which was not in itself the only source of wastes. The effect of a plant closure would not have cleared up the problem at Prince Albert for a matter of several weeks.

During the winter of 1953-54 a large amount of work was done to ascertain in this plant and from the other industries in the Edmonton area the source and the strength of the odours in their wastes, and to try to correlate these with the odour numbers in the river. The results of some of these odour tests are given in Table 5.

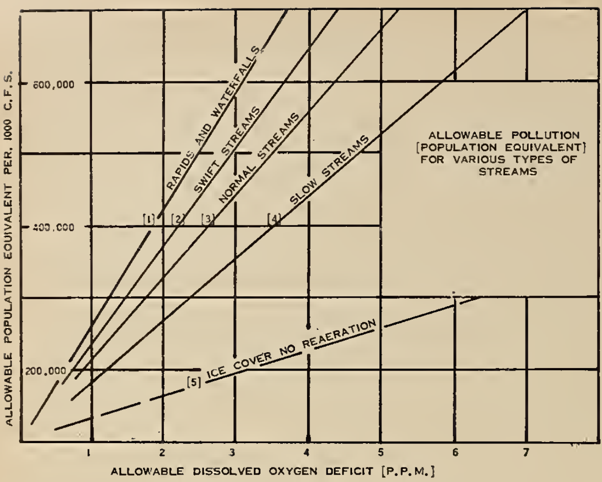


Fig. 2. Allowable Pollution for Various Types of Streams.

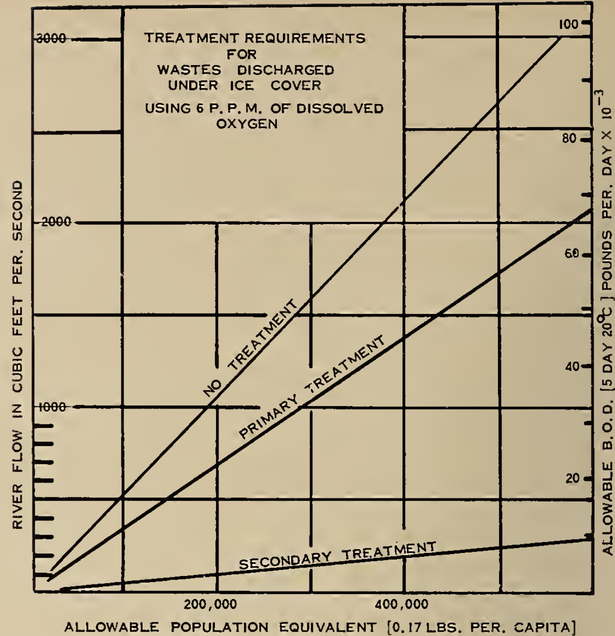


Fig. 3. Treatment Requirements for Waste Discharged Under Ice Cover.

At the same time other factors such as B.O.D., solids, colour etc. were being checked. Previously, some studies had been made as to the B.O.D. and the effect on the oxygen in the river, and an order had been issued to the City of Edmonton to improve sewage treatment facilities. Since this project necessarily involved financing arrangements as well as the time necessary for the drawing of plans and the construction of the plant a target date was set as the fall of 1954, at which time the City was to have the installations in working order.

There was little improvement in the river during the winter of 1953-54. In the spring of 1954 all of the industries in the area as well as the City met with the Provincial authorities to examine the data obtained and to plan the steps necessary to improve the quality of the river.

As a result of these meetings and the full co-operation of industry involved, standards were adopted for the river and permissible amounts of pollution were allotted to the city and industries. On the basis of the allowable loading of B.O.D., the City was allotted 60%, the Industries 20%, and 20% was left for meeting the needs of the future. The effluent quality standards required were comparable to those adopted by the International Joint Commission Report of 1951. In essence it meant that each industry was providing the maximum reasonable treatment for its waste. The word 'reasonable' here is from the outsiders' point of view, and not that of industry, although industry took steps to meet these requirements. For example one oil refinery was permitted an allowable phenol of 3 lb. per day. When one considers the complexity of the operation and the large number of possible sources of phenols in an oil refinery, one might wonder about the relative truth of the word 'reasonable'. In one refinery phenols (carbolic acid) is used in carload lots and yet they were to allow only a few cupfuls to reach the river. This is an example of the critical nature of some industrial wastes; a tolerable limit of 5 p.p.b. of phenols in a river flow of 600 c.f.s. is only 16.3 lb. per day.

In the Edmonton area the industries approached the matter of waste reduction on a physical rather than on a biological treatment basis. That is to say, isolation of the waste as far as possible, burning of those portions which were particularly offensive, and in many cases ponding of the effluents. This has worked out quite well. Ponding of effluents, or that portion of the effluent which causes the most pollution, decreases the pollution in the winter period of low flows. In the spring and summer these ponds may be drained with no ill effect on the receiving stream which at that time is open for reaeration and has a much greater volume of flow. The rate at which these ponds may be emptied is related to river flows in such a way that the permissible concentration of pollutants in the river does not exceed the limits recognized as being safe for a water which is to be used as public water supply.

The City of Edmonton has built a secondary sewage treatment plant, placed in operation in the fall of 1957. The plant is now operating at an efficiency of over 90% removal of B.O.D. One of the problems presented at the city treatment plant was the large amount of packing house wastes which was difficult to treat, in that there was a large amount of fat and considerable suspended solids which constitute enough bulk, that the digestion tanks were taxed to their full capacity in the first year of operation. Since that time the City has required that the packing plants provide primary treatment at the plant, briefly the removal of fats in settling tanks and screening of the effluent by fine screens so that the straw, paunch manure, and hog bristle, is largely removed at the source. In addition to this the City has required that all industrial plants pay an extra amount for the treatment of their wastes, this amount being based on the cost of the treatment at the city plant. The sewage treatment plant is operated as a primary treatment plant in periods of open water. This creates a substantial saving in the cost of power required to operate the blowers of the activated sludge secondary treatment section of the plant.

In spite of the improvements in waste treatment carried out before the winter of 1955-56 the dissolved oxygen in the river that year was reduced to zero at points 100 miles downstream. This caused a pronounced septic odour in the river. It not being possible to speed up the construction of sewage treatment works, the Provincial Government with the co-operation of the City of

Edmonton undertook a project to aerate the North Saskatchewan River using compressed air. A 2,000 c.f.m. blower was set up on the river about 40 miles downstream from Edmonton and distribution pipe placed through the ice, and air injected into the river.

The difficulty of aerating cold water under adverse conditions was realized. It was felt however that the air injected might be trapped under the ice surface and absorbed over a longer stretch of the river. This work was described in detail in a report prepared by Wm. Bailey, of the Division of Sanitary Engineering in 1956.

The data showed an increase in the dissolved oxygen content of about 0.5 p.p.m. at a river flow of 1,060 c.f.s.

The two most basic pollutants on the North Saskatchewan River are those with a high B.O.D. and those with odours or odour-producing substances. The results of controls on phenols and odours are shown in Table 6.

The situation with regard to the dissolved oxygen content in the river and the reduction in the oxygen-demanding materials is shown in Fig. 4. Whereas in 1954 the B.O.D. exceeded the dissolved oxygen, in 1960 the B.O.D. is considerably lower than the dissolved oxygen content; the flow in 1954 and in 1960 was approximately 1,400 c.f.s. at the sampling period. Fig. 5 is an interesting plot showing the decrease in dissolved oxygen as the river flows downstream from Edmonton. These curves are drawn from data based on 24 hr. composite samples, hourly samples being taken. The slope of the curves indicates the rate of the B.O.D. reaction under ice cover. The time of flow from Edmonton to Lloydminster is estimated at 14 days when the flow is 1,000 c.f.s. under ice cover.

In spite of the improvement in the waste treatment in the Edmonton area it is quite evident that at extreme low winter flows present loadings would again cause a serious condition of pollution in the North Saskatchewan River. In spite of more efficient treatment it is apparent that at some time in the future, the best relief for the problem would be to augment the winter flows in the North Saskatchewan River. In general the installation of hydro projects works well for this purpose. Discussions have taken place between the Alberta Government and Calgary Power regarding the possibility of developing hydro-power on the headwaters of the North Saskatchewan. This could increase the average winter flow in the North Saskatchewan to about 3,000 c.f.s. and would approximately triple the average of the low flow months in winter. It will be of some four times the once-in-ten year low flow of about 700 c.f.s., making a tremendous difference in the allowable pollution load on the river.

TABLE 6

Phenols and odour numbers North Saskatchewan River below Edmonton

	1954 Phenols p.p.b.	*1954* Odour T.O.N.	*1956* Phenols p.p.b.	*1956* Odour T.O.N.	*1960* Phenols p.p.b.	*1960* Odour T.O.N.
Beverly Bridge...	110	8	2 to 6	4 to 16	8	10
Ft. Saskatchewan	55	15	0 to 2	2 to 32	4	8
Lloydminster.....	4	16	0 to 2	4 to 200 (septic)	—	8

The Battle River

The Battle River is a very small stream which has a low flow of the order of 0.1 c.f.s. There are no great sources of pollution on this river but the allowable would be quite low. The Battle River is the natural runoff from Pigeon Lake. At various times there have been some suggestions that this lake be used as a source of water supply for the Edmonton area. The limited amount of water would not meet 10% of the water requirement in that area. There is a considerable amount of water for domestic or industrial use but a shortage of water for dilution of the wastes.

The Red Deer River

The Red Deer River flows through the City of Red Deer and then on through Drumheller to Empress and the South Saskatchewan River. The City of Red Deer which has expanded greatly in the last decade is the major source of waste flowing into the river. There are several industries in the City, the main ones being a milk plant and a brewery. Checks on the river have been made and there is a noticeable drop in the dissolved oxygen below the City of Red Deer. Using the minimum 10 yr. flow it was estimated that there was a need for primary treatment of the sewage. The City of Red Deer has been advised of this necessity for treatment and is now proceeding with plans. The City of Drumheller is some distance downstream and checks have been made at that point since the river is used as a source of water supply. The bacterial counts are low enough to be in the range that ordinary treatment of the water will provide a domestic supply which will meet the usual drinking water standard.

The Bow River

The Bow River is a tributary of the South Saskatchewan. It flows through the City of Calgary. Although the quality in the Bow River is good it does not serve as the source of supply for the City. The Elbow River which is smaller in size has for many years served as the source of supply from a reservoir created by the Glenmore Dam.

The Bow River has in the vicinity of Calgary many of the features of a mountain stream. The water is clear, the river bottom is clean and gravelly, and the stream has an abundant supply of rainbow and cut throat trout.

The first work on the Bow River was done in connection with com-

TABLE 5

Representative Data for Industrial Waste Streams in the Edmonton Area

Source	*1954* Odour Number	*1954* Phenols p.p.b.	*1954* Waste Flow m.g.d. (Imperial)	*1960* Odour Number	*1960* Phenols p.p.b.	*1960* Waste Flow m.g.d. (Imperial)
Oil Refineries						
I.O.L.	100	10,000	1.9	250	170	2.0
B.A.	100	4,500	0.275	150	110	0.5
McColl	400	20,000	1.1	50	27	0.6
Other Iudustries						
C.I.L.	400	250	0.05	2,000	940	0.05
Can. Chemical	1,000 to 2,000	—	3.5	100	60	3.5
Building Production	500	40	.003	400	860	0.003

plaints that the fish in the river below Calgary for a stretch of about 50 miles tasted oily, and a very active section of the Alberta Fish and Game Association had for many years been trying to have this matter cleared up. It was found that the oily taste in fish was in proportion to an oily odour in the river. The oil odour persists for a distance of about 40 miles below Calgary. While studies of this taste problem were being made additional data were being obtained as to the general loading on the Bow and an estimate was made as to the required treatment in Calgary. As a result of these studies the City of Calgary has installed a treatment plant to replace one which for many years had been overloaded. It was found that on the basis of the dissolved oxygen content alone the City might have put off treatment of waste. The character of the river and the fact that it was used for fishing and that there were residences along the river downstream from the City required that the visible material in the sewage be taken out. Furthermore, there was considerable material which was stranded on the banks as the stage of the river rose or fell.

Industrial wastes flowing to the City sewers include those from three packing plants, a distillery and a brewery.

There were a few interesting points in connection with the Bow River. In the first few years of study some emphasis was placed on the bacterial counts in the river since it was used as a source of water for the Town of Bassano some 100 miles downstream from Calgary. While at that time the population of the City was about 130,000 and only a portion of the sewage received any treatment, it was a surprising fact that the coliform count in the raw water at Bassano was less than 2,000 per 100 ml. This might be accounted for by the fact that the river was fast and clear and that the biological slime on the rocks acted in the same way as that in a trickling filter.

In regard to the taste in the fish this was verified by placing fish in cages at various points along the river and making taste tests. There is an oily smell to the water in the river and the fish seem to retain this in their flesh. If the fish are removed from the water for a few days this taste will disappear. In 1958 laboratory scale tests were made using refinery effluents and various concentrations of phenols. While there are several factors to be considered the main conclusion was that an odour number in the water of four, the fish would pick up the oily taste in one day.

Pure phenol did not produce taste in the fish, exposed for several days to concentrations close to toxic ones. Details of the test procedure and data obtained are given in a report written by the Division of Sanitary Engineering in co-operation with the Fisheries Division of the Alberta Government (1958).

There is little doubt that the refinery effluents are responsible for the major amount of the oily odour. Odour numbers have been made on refinery effluents and they will at times reach about 2,000. How to remedy the situation is a problem, since there are no previous data on the removal of odours from refinery effluents. The odour of oil is one of the most difficult to remove. The refinery waste is quite low in oils, the effluent running 10 to 15 parts per million, a figure which compares well with any other refinery and with the standards set by many stream sanitation authorities. The refineries, as new sections of the plant are added, are taking great care in the design to see that leaks are readily detectable and that treatment of the waste is well designed. Work is continuing on this project.

The Bow River stays open for a considerably longer period of the year than does the North Saskatchewan and there are usually some open spots, at the rapids and at the two dams below Calgary. The power installations of Calgary Power have increased the winter flows to about 2,000 c.f.s giving the Bow River more winter capacity than the North Saskatchewan. At the present time primary treatment only is provided in Calgary. The status of the river is being checked so that secondary treatment will be installed when necessary.

Among the other effluents which flow into the Bow in the Calgary area is that of a nitrogen plant. This plant effluent could at times have a high carbon dioxide content and a low pH. This problem is taken care of by aeration through falls in the effluent channel. This is sufficient to reduce the carbon dioxide content in the effluent to a point where it will not produce fish kills, of which there had been a few local ones in the past, in the area near the mouth of the waste channel.

The Oldman River

The Oldman River has its head waters in the Crowsnest Pass area and flows easterly through Fort MacLeod, Lethbridge and Taber. One of the main tributaries is the Crowsnest

Fig. 4. Dissolved Oxygen and Oxygen Demand — North Saskatchewan River at Fort Saskatchewan.

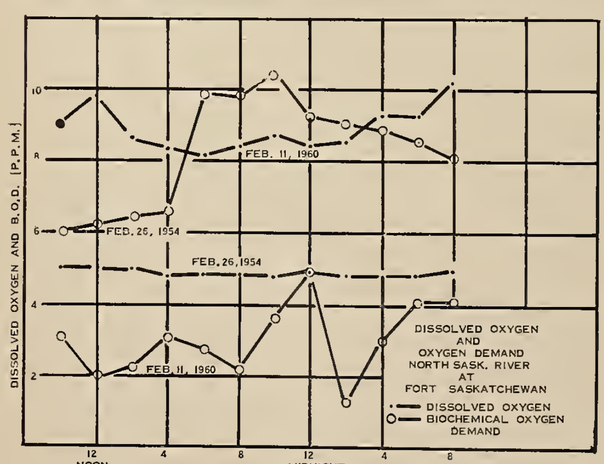


Fig. 5. Residual Dissolved Oxygen — North Saskatchewan River.

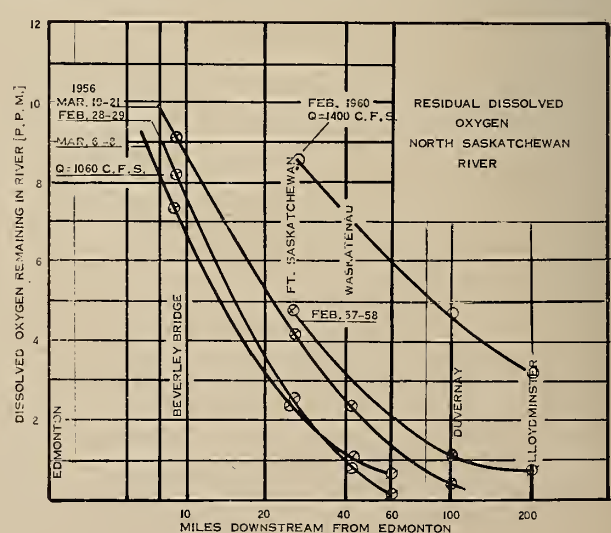


TABLE 7
Representative data on Bow River

Sampling Point	*B.O.D. p.p.m.*	*D.O. p.p.m.*	*M.P.N. Coliform per 100 ml.*	*Odour No. (T.O.N.)*
Above Calgary	0.6	10–12	344	1
10 miles below Calgary	2.1	8–10	22,000	20
40 miles below Calgary	2.1	8–11	6,000	10
100 miles below Calgary	1.7	8–10	1,900	4

River, which flows through an area where coal mining has been the main industry for many years. The effect of the coal mining has been that many of the streams at certain times of the year contain fine coal dust. The main method of controlling this is to have the wash water at the tipples ponded.

In the last decade strip mining and the use of heavy machinery has replaced the underground workings to a great extent. A considerable amount of fine coal is left on the sides of the strip mine and on the surrounding area from the handling of the coal. When there are rains, this dust is washed down into the streams. In one case beaver dams have had a very good effect in retaining the coal dust so that it does not reach the main stream. The effect of coal dust on the main streams is that it may be a problem if the stream is used as a source of water with very little in the way of treatment. The coal dust also covers the bottom of the stream so that the natural life on which fish feed is not present. These streams in their natural state abound in rainbow and other trout.

At Pincher Creek there is some pollution from the wastes from the Town but it is relatively small.

At Lethbridge there is a growing pollution load. Part of this load is in connection with the vegetable canning and freezing industry. One fortunate aspect of the situation is that the wastes from the canning industry and also from the sugar refining, occur seasonally and in the period when the river is open. The sugar campaign ends about the end of December at which time there is a good chance that the river is still open. The canning and freezing season ends in September. Data on the pollution loads on the Oldman in the vicinity of Lethbridge are given in Table 8:

The Town of Taber is located not far below Lethbridge and a fairly close watch has been kept on the river so that the raw water at Taber would be in a condition where it could be treated for domestic water supply.

The South Saskatchewan

The Bow River is confluent with the Oldman below Taber and from that point on the river is known as the South Saskatchewan. It flows through Medicine Hat and into the Province of Saskatchewan. At the City of Medicine Hat, the main waste is the domestic sewage from the City. One of the larger industries is a producer of chemical fertilizers. A careful check has been made on the effluent from the fertilizer plant to make certain that the fluoride content in the South Saskatchewan is kept low.

The previous pages have covered the rivers of the Province. There are possibly two other questions which might arise in the mind of the reader. What of those towns which are not located on these rivers and what of the effect of the oil industry on the pollution in the province?

For many of the towns in the province the method of treatment of sewage is by means of long detention sewage ponds. This is by far the best method, on the basis of economics, reliability of the treatment, and from the standpoint of reducing the pollution load on the rivers. Of the 177 cities and towns in the province with sewerage systems there are 114 which use ponds as a means of treating their sewage. Most of these ponds retain all of the sewage flow during the winter period and may be drained during the spring and summer.

The effect of refinery wastes on the rivers has been discussed but what of the oil fields themselves? There is relatively little water pollution from oil field operations. Regulations of the Oil and Gas Conservation Board require that all waste oil be caught in catch basins and it is usually burned (causing some spectacular smoke columns). Similarly salt water is either retained in sumps or collected by pipeline and returned underground. Associated with the gas industry are the sulphur plants and gas processing plants. The volume of waste water from these plants is small. There is however the problem of keeping the odour number of these wastes low so as to preserve the few streams which we have as a source of domestic water supply. Small amounts of hydrocarbons and mercaptans produce odours and tastes in waters which are very difficult to remove.

Gravel washing plants must pond their waste so as to remove most of the silt prior to disposal in a stream.

One could not leave an article of this type without attempting to make some estimate for the future.

The lack of large volume of water in Alberta, for water supply and particularly for waste dilution will become increasingly evident. More effort will have to be made to reduce pollution loads particularly in the winter season.

One method of accomplishing this may be to pond entire waste flows over the winter, even for such large industries as a pulp mill. Another is development of hydro power as a means of increasing the minimum flows in the rivers. Disposal of wastes to deep underground strata may be used in some cases.

It must be pointed out that there are many industries which have no waste disposal problem, so that industrial growth can be maintained in these industries in spite of lack of large water resources.

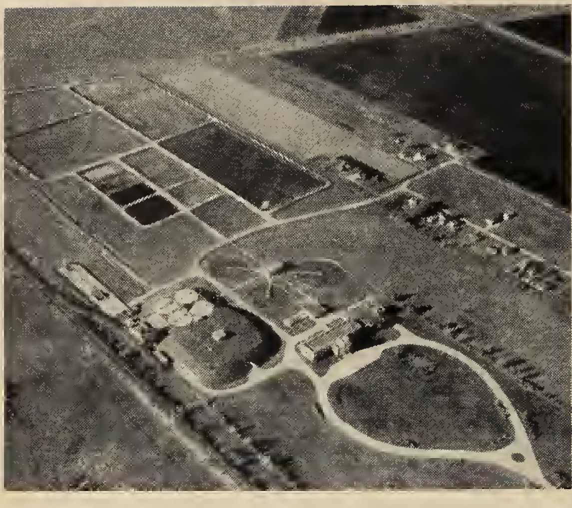
Abbreviations

B.O.D.—Biochemical Oxygen Demand — given in parts per million by weight.
P.P.M. or p.p.m.—Parts per million by weight.
p.p.b.—Parts per billion by weight.
D.O.—Dissolved Oxygen.
c.f.s.—Cubic feet per second.
°C.—Degrees Centigrade.
T.O.N.—Threshold Odour Number — The dilution required to reduce the odour in a waste sample to a point where it can no longer be detected.
m.g.d.—Million gallons per day.
M.P.N.—Most Probable Number — as used in coliform counts in bacterial tests.

TABLE 8
Representative data on Oldman River (for open water conditions)

Sampling Point	*B.O.D. p.p.m.*	*D.O. p.p.m.*	*Odour (T.O.N.)*
Above Lethbridge (Oct./59)	1.8	10.5	2
Immediately below Lethbridge (Oct./59)	3.7	10.6	3
Above Taber	5.2	10.4	2
Below Taber (Oct./59)	7.7	9.4	2
Above Medicine Hat	1.9	10.5	1
Below Medicine Hat	2.2	10.9	2

Note:—Values of B.O.D. below Taber are partly due to wastes from the sugar refinery.



THE GREATER WINNIPEG SANITATION DISTRICT AND RIVER POLLUTION ABATEMENT

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The explosive population growth with its accompanying development of suburbia and the tremendous expansion and almost undreamed-of development of industry which has taken place since the end of World War II, have been the main factors in forcing more Canadians to take an increasing interest in the conservation of our greatest and most important natural resource, Water, by control of pollution. This paper is devoted to the Greater Winnipeg Sanitary District, its organization, the original works constructed, the changes which have taken place including extensions as well as its expanded activities and finally, the plans and indications for future development, all of which may be considered more or less typical of the development of pollution control in this Country during the last quarter of a century.

METROPOLITAN Winnipeg is located at the junction of the Assiniboine River and the Red River of the North and comprises some 16 municipalities with a total area of 264 miles and a population of some 450,000 people. The area's sewerage systems initially and later the sewage disposal treatment facilities developed in the usual orthodox manner.

The City of Winnipeg built its first sewer in 1876 just two years after the City's incorporation. More sewers were added soon after, but by 1882 it was evident that a more comprehensive system was necessary and the City Engineer of Chicago was called in to make a report. On the basis of this report, the City was divided into 21 districts, each drained by a main trunk sewer, emptying either into the Red or the Assiniboine rivers. All of these trunk sewers were of the combined type and the great majority were built by 1914. The other municipalities in Greater Winnipeg dealt with their sewage in a similar manner.

When sewage is discharged into a body of water, certain chemical and biological reactions take place and if the amount of water and the quantity of oxygen dissolved in it is sufficient, the sewage will be oxidized and the water will become purified through the operation of natural phenomena. This method of sewage disposal is known as the 'dilution method'.

Generally speaking, the volume of water flowing in any stream and the amount of oxygen contained in that water is a measure of the capacity of that stream to assimilate and purify the sewage which may be discharged into it. If the quantity of sewage is not too great or too strong, it will be purified and no nuisance will be created. However, if the character of the sewage is very strong or if the quantity is greater than the diluting ability of the water into which it is emptied, then a nuisance results and fish and fauna cannot survive.

Organization of the Sanitary District.

Until the 1930's, with the population remaining fairly static, Greater Winnipeg got along quite well with this system of disposal, but drought years at that time caused abnormally low flows to the river. In one month in 1934 more sewage was discharged into the Red River from the Winnipeg sewer system than was flowing in the river itself. In addition, the population was beginning to increase and industrial development was growing rapidly, with the result that the rivers virtually became open sewers.

This condition and the Federal Government's policy of establishing unemployment relief projects resulted in the passage of the Pollution of Waters Prevention Act in 1935 and in the establishment of the Greater Winnipeg Sanitary District by an Act of the Legislature, also in 1935, to undertake the treatment of Greater Winnipeg's sewage.

It might be mentioned that the organization of the Greater Winnipeg Sanitary District was one of the first cases in North America and the first in Canada where a metropolitan corporation was established to collectively treat the sewage from a number of contiguous municipalities.

When the Act was drawn originally and was presented in the House, it included the nine member municipalities constituting the Greater Winnipeg Water District, which at that time were the only municipalities with sewerage systems discharging into the rivers. However, before final passage of the Act an escape clause was included which permitted any municipality to withdraw from the District within thirty days of the Act's proclamation. In retrospect it became clear that the inclusion of this escape clause was a very serious mistake. Six of the nine municipalities took advantage of it and withdrew from the District. Three of these municipalities rejoined very shortly after, but the other three remained outside the District until 1955. This naturally created some grave problems which will be described later.

Type of Treatment.

Excluding sewage lagoons, the simplest and least expensive method of sewage treatment is known as primary treatment. In this process, the inert grit or inorganic solids are first removed and disposed of, usually by burying. The sewage is then passed through settling basins to remove all organic solids that will settle by gravity alone and the liquid is allowed to pass on to the receiving body of water. The settled sewage solids, called sludge, are then treated in various ways to render them inert and inoffensive before disposal. The primary type of treatment is based on the accepted principle of dilution already mentioned, to purify the liquid part of the sewage.

Where necessary, primary treatment is followed by additional or secondary treatment. The liquid or effluent from the primary process is given further treatment to remove practically all of the remaining solids and in certain cases, the final effluent is given additional treatment by chlorination or otherwise so as to render it completely stable.

Original Works — The District's first consulting engineer, the late Mr. W. S. Lea, M.E.I.C., of Montreal, was charged with the responsibility of designing the system of sewage treatment that would most economically meet the District's requirements. On the average, with the exception of periods of drought, there was sufficient river flow available to meet the minimum requirements for good dilution. Because there were no bathing beaches, no fisheries of any value and no communities drawing their water supplies from the river downstream from the treatment plant, he recommended that only primary treatment was to be provided initially, although some provision was made for the construction of secondary treatment facilities later if required.

One of the first problems that have to be determined in the design of such treatment works is to decide the requirements of present conditions and the provision to be made initially for future growth. It is obvious that some economic balance must be struck to make sure that the works will not have to be enlarged too soon, and at the same time, that not too great an economic burden is placed on the community by providing for works too far in the future. The usual yardstick used is to provide approximately for 30 to 50 years' capacity in those structures that are not easily enlarged or duplicated, such as the interceptors and basic structures, and to provide for 10 to 15 years' capacity for those parts of the works that can be easily enlarged or added to, such as pumps and comminutors at the pumping stations and clarifiers and digesters at the treatment plant. On this basis, the interceptor was designed to take care of a future population of 585,000 with a flow capacity of 160 m.g.d. (U.S.), whereas the plant itself was designed for a capacity of 25 m.g.d. (U.S.) to serve immediately an equivalent of a population of 278,000, and was intended to take care of the community's requirements until approximately 1945 with provision for enlargement to serve an equivalent population of 585,000.

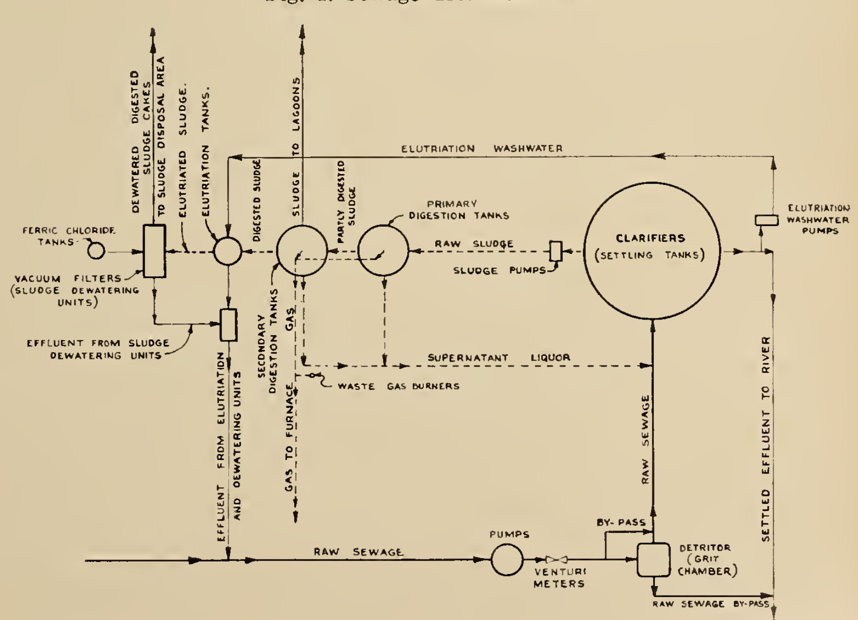
The treatment plant was constructed, in the northern part of the area, well downstream of the then developed area. It was necessary to build intercepting sewers approximately parallel to both rivers to collect the sewage and convey it to the treatment plant. The main interceptor runs along the north side of the Assiniboine and along the west side of the Red. Because of the flat terrain, construction difficulties and economic considerations, it was impracticable to build the interceptor deep enough for all trunk sewers to deliver into it by gravity. It was necessary therefore to construct 16 pumping stations and eight river crossings, two in the Assiniboine and six in the Red.

The original design called for all sewage to be screened and cut up before being discharged into the interceptor. This was accomplished by 24 comminutor stations, 16 of which were combined with the pumping stations. No screening is undertaken at the main plant.

The works originally constructed provided for the following processes of sewage treatment: grit removal, primary settling and separate two-stage digestion followed, by elutriation and vacuum filtration. As the sewage arrived at the plant, some 55 ft. below grade level, it was lifted by low-lift pumps installed in two of three pump wells and passed through a grit removal unit and then to two clarifiers or settling basins. The primary sludge was then pumped to the digesters in which heating coils were installed. Following two-stage digestion, the sludge was elutriated or washed with clarifier effluent to reduce its alkalinity, then vacuum filtered after conditioning with ferric chloride. The dried sludge was ultimately disposed of as a soil builder to market gardeners and others. Provision was made for the installation of additional pumps in the third pump well, the addition of a second grit removal unit, two clarifiers and more digesters. The plant flow diagrams are shown in Fig. 1 and 2.

Subsequent Extensions — As mentioned, it was estimated that the original plant would be adequate until

Fig. 1. Sewage Treatment Plant



1945. However, as a result of World War II and the rapid increase in industrial activity, particularly the packing industry, certain sections of the plant became overloaded by 1942. Due to the War itself and to the restrictions during the rehabilitation period after it, no expansion was undertaken. By 1947 it was obvious that prevailing conditions were not entirely satisfactory. The Provincial Sanitary Control Commission, after discussing the matter with the Sanitary District and the three non-member municipalities who had withdrawn from the District at its creation in 1935, engaged the services of a prominent firm of consulting engineers, Alvord, Burdick & Howson of Chicago, to investigate the situation and make a report.

Two reports were prepared. In one, the consulting engineers reported on operations of the Greater Winnipeg Sanitary District and recommended additions which should be made to the District's facilities in order to provide sufficient capacity. In the second report, they strongly recommended that the sewage from St. James, Fort Garry and Tuxedo outside the District should be treated, and outlined several methods which could be used. One of these was that they rejoin as members.

Following these reports the Provincial Sanitary Control Commission negotiated with the non-member municipalities and the District, with a view to having the recommendations implemented. The non-member municipalities claimed that they were not able to re-enter the District on the financial terms outlined in the consulting engineers' report. Yet on the other hand they did not proceed with the alternative of providing facilities of their own. Under protest, the District agreed to accept the recommendations of the consulting engineers' report concerning the additional facilities which the District should provide, but at the same time demanded that the non-member municipalities should come forth with some plan for taking care of their sewage.

In 1950 the District engaged the firm of Alvord Burdick & Howson to prepare plans and specifications for the extensions required, and when steel became available after the Korean War these works were constructed. Further discussion took place between the three parties, but action did not result until early in 1954, when the Provincial Government stated categorically that it would amend the Sanitary District Act to include the three non-member municipalities and that they would be given until July 1st to work out arrangements with the District for their re-entry; if this could not be done by mutual consent, then the Lieutenant-Governor in Council would specify the terms of their inclusion. Shortly thereafter, mutually satisfactory terms were worked out whereby the three non-member municipalities were permitted to re-enter the District by making back payments equivalent to the amount that they would have paid over the previous 18 years if they had remained in the District. One municipality made this back payment in a single cash payment, while the other two are making annual payments over a 20 yr. period at low rates of interest. On January 1st, 1955, they became full and equal members of the District.

Since 1955, extensions and additions have been made to the original works constructed. The main interceptor has been extended by 1.7 miles and 4.5 miles of secondary interceptors and force mains have been constructed. Seven additional comminutor-pumping stations have been added to the original 24, and six stations have been enlarged. At the treatment plant itself, a 35 m.g.d. pump was installed increasing the pumping capacity by 40%; a second grit settling unit was installed and an additional 145 ft. clarifier was constructed increasing the settling capacity to 42 m.g.d. from 25 m.g.d.; four 85-ft. diam. digesters were constructed tripling the digestion capacity by adding 600,000 cu. ft. to the original 300,000 cu. ft. It was estimated that this would provide sufficient capacity to take care of the population until 1963-1965.

Studies have now been completed which indicate that all of the existing sewers that can be connected to the present treatment plant will have been so connected by 1960. It has also been decided that at least one additional plant will be required; a site has been selected and expropriation is proceeding to secure it.

Special Provisions of District's Act.

The District's Act which was originally passed some 25 years ago had certain farsighted and unique provisions which enabled the District to undertake and extend its functions and activities during the very rapidly changing conditions which have developed over the last few years and might therefore be worth mentioning in this paper. Three of these are: sewer rentals, industrial wastes control and the development of separate sewered systems.

Sewer Rentals — Section 31 of the Act clearly sets out how the District is to obtain its revenues and how they shall be passed along to the sewer users. In October of each year, estimates are prepared of the following year's operating costs and in these costs are included principal and interest payments on the capital debt. The total amount of these estimated costs is then divided pro rata among the member municipalities based on the estimated amount of sewage to be contributed by the municipalities during the following year. In estimating this amount of sewage, the District is permitted to use the water consumption of each of the municipalities for the previous 12 month period of October to September as equivalent to the sewage contribution. These allocations are then levied upon the municipalities and have to be paid quarterly to the District.

Section 31 of the Act then specifies clearly and concisely how the municipalities in turn are to obtain the money for their allocation. This is done by enacting a by-law which imposes a sewer rentals charge on the occupier of any premises using water; this is collected with the water bill. In addition to the amount for the allocation, the municipality can only add an administrative charge for collection. Any surplus collected cannot be used for other purposes but must be kept in a separate reserve fund and used for decreasing future sewer rental charges. The Section further states clearly that none of these charges may be assessed as a levy against land.

This method of financing and collecting the costs of sewage treatment has proved effective, equitable and simple to administer.

Industrial Wastes — Just as is the case with other similar Authorities [2,3,4], one of the major problems with which the District had to deal with was that of industrial wastes. From the start of operations in 1938, considerable difficulty and expense have been caused in the collection system and at the treatment plant by industrial wastes of one kind or another discharged into the sewers.

Prior to the construction of the treatment plant, all industrial wastes which could physically be discharged to the sewers were disposed of in this fashion and then into the rivers. As a matter of fact, it was this condition that turned the rivers into virtual septic sewers during the low water years in the 1930's and resulted in

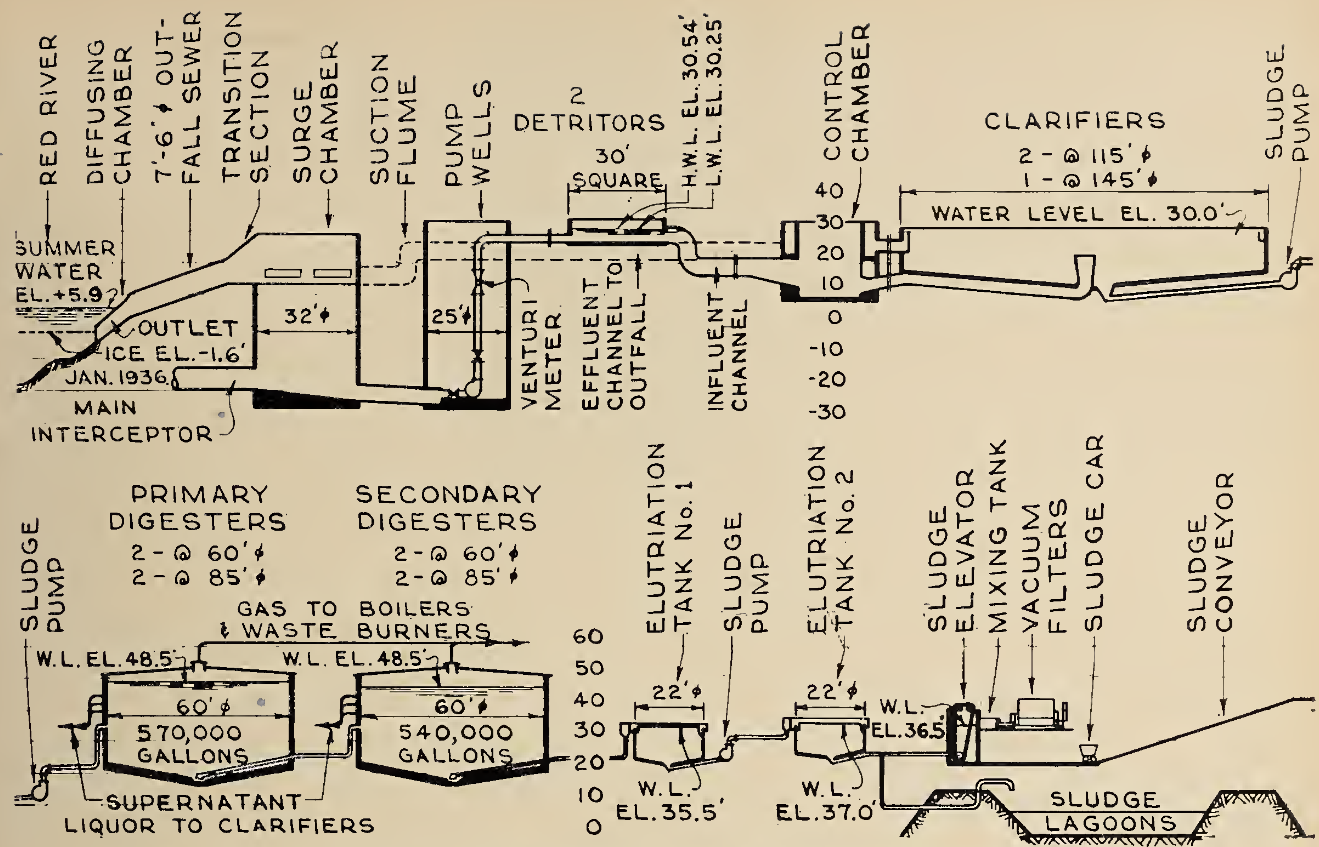


Fig. 2. Section profile through Sewage Treatment Plant showing present installation of 42 m.g.d. (US)

the serious nuisance which then prevailed.

It is not generally realized by the layman that the amount of water used by industries is very large, and that the wastes from many of them contribute a very high equivalent population loading. A few instances may be cited. For every barrel of beer produced in a brewery, about 285 gal. of water are required for processing. For every steer that is processed in a packing plant, 300 to 800 gal. of water are required. For every barrel of oil produced in a refinery, 800 gal. of water are required. Almost all of this water becomes highly polluted in processing and then has to be disposed of, a none too easy task, and the simplest solution is to discharge it to the sewers.

It is therefore quite understandable that these practices which had grown up over the years were difficult to break, especially when the only alternative meant the installation of costly equipment to separate the objectionable wastes and further costs in disposing of it by other means. Winnipeg being the centre of an agricultural area, food processing is one of the major industries and this type of industry produces some very strong wastes. The following examples will give some indication of the magnitude of the waste contributed by industry. Waste from a slaughterhouse-meat packing plant of which Winnipeg has six, will range from a population equivalent of 20,000 to 90,000. The waste that is produced by our beet sugar plant with a capacity of 2000 tons of beets per day, results in wastes approximately equivalent to that from 125,000 to 130,000 people.

Consequently the District was faced from the start of its operations with a real problem in dealing with the wastes discharged to the sewers from various industries. In the original Act, Section 19, the District was given powers to regulate, control and prohibit the discharge of various materials to the sewers, and over the years it has gradually evolved a philosophy on the control of industrial wastes which finally culminated in the passing of By-law No. 80 in August 1957.

Initially, the abattoirs and meat packing plants were the greatest local offenders. The fable of their efficiency to the effect that "they use everything in the pig but the squeal" was unfortunately somewhat exaggerated. The discharge of large quantities of paunch manure, grease, pig's toe nails, etc., resulted in clogging the sewers and plugging the comminutors and pumps. On reaching the treatment plant, the wastes caused further trouble. Frequently, a blanket formed on top of the clarifiers which in cold weather would freeze. In the digesters, a scum blanket in excess of 8 ft. in depth formed, and was most difficult to break up. This required the emptying of the digesters, which is quite a dangerous and unsatisfactory procedure.

An educational program was first tried in order to persuade the various industries to co-operate. With the outbreak of War in 1939, not very much could be accomplished. Following the War, further steps were taken to try and obtain voluntary co-operation and in addition By-Law No. 38 "A by-law to prohibit the discharge into sewers within or entering the Greater Winnipeg Sanitary District of certain detrimental materials and slaughterhouse and packinghouse wastes", was passed in July of 1945.

By 1950, it was apparent that the District's facilities required enlarging and that a more aggressive control program would be required if the treatment facilities were to be capable of proper operation and the additional costs to be paid for on a more equitable basis. While Section 19 of the District's Act provided for the imposition of surcharges for extra strong sewage, these had never been implemented. The District's consultants recommended against the implementation of such charges, feeling that they would discourage the various industries from constructing pre-treatment facilities, but did recommend that screen chambers at the outlets from each of the packing plants be constructed at the District's expense. The screen chambers were constructed later and in addition the following two by-laws were enacted in 1954:

By-Law No. 64—A By-law to prohibit the discharge or drainage of sewage within the District into any river flowing through or adjacent to the District.

By-Law No. 65—A By-law to prohibit, regulate and control the discharge of industrial and factory waste or excessive amounts of any type of sewage or waste water.

Both of these by-laws make provision for licensing. In the case of By-Law No. 64, every person, that is, industry or municipality must obtain a license for any outlet into a river including storm sewers. In the case of By-Law No. 65, it is mandatory for every industry to obtain a license from the District before discharging any industrial waste or large quantity of sewage or waste water into the sewers. It follows the model by-law developed by the Water Pollution Control Federation [7], and sets out the various types of material prohibited and the standards and normal limits of permitted materials such as B.O.D., suspended solids, grease, etc. It also gives the General Manager of the District discretion to permit the discharge of sewage of a greater strength under certain specific conditions. This by-law permits the installation of domestic garbage grinding units in residences but requires that all larger industrial or commercial units be licensed.

While the screen chambers worked reasonably well in preventing large particles, pig's toe nails and a certain amount of paunch manure from being discharged into the sewers, it was still found that the effluent from packing plants was of a very high strength, particularly in B.O.D. and grease. It was then decided to review the matter of surcharges and after a considerable study of the various methods of regulations and formulas used by similar authorities, the District developed a formula of its own for imposing such surcharges. This was incorporated in By-Law No. 80 "A By-Law to provide for surcharges for the discharge of factory and industrial wastes into sewers or rivers within or entering the District." It was passed in August 1957 and became effective on January 1st, 1958. This by-law is a counterpart of By-Law No. 65 and is applied in conjunction with it. Where the District can accept wastes stronger than the set limits and agrees to do so, surcharges are applied in accordance with the formula.

The District's philosophy in making these surcharges was based on the fact that while industry and the community form a natural partnership, this partnership should be an equitable one. The community naturally wanted to see the development of industry since this provided employment for the population and gave an excellent source of tax revenue. Industry on its part naturally wanted to co-operate with the community in order to obtain a market for its products and to have available a labour force. But it should not be subsidized or expect to be subsidized by the community in having its stronger wastes treated on an equivalent basis to that of normal domestic sewage. As long as the District could, it was prepared to permit the discharge into the sewerage system of acceptable industrial wastes of higher than normal strength and to impose surcharges for the additional strength. Knowing the basis of the surcharges, industry could then decide for itself whether it was more economical to provide the necessary pre-treatment to meet the District's standards or only provide minimum pre-treatment and pay the surcharges.

This by-law has now been in effect just over two years, and during this period of time all the packing plants, slaughterhouses, paper mills, breweries, dairies, tanneries and miscellaneous food processing plants such as honey, potato chips, vegetable packing, etc., have been licensed: surcharges have been imposed upon 30 of them.

We can now definitely state that from our experience with this surcharge program it has proved successful, is based on sound principle and is reasonably equitable and not too difficult to administer. We also feel that industry believes us to have been fair and has accepted the plan reasonably well, particularly when one bears in mind the natural reluctance to have to spend money on something that was formerly done at no cost and tended to be considered a non-productive nuisance.

The following are the general effects of the program:

1. There has been a definite reduction in the strength of the sewage going to the sewers as witnessed by the fact that of the industries being surcharged, the B.O.D. has been reduced 30.7%, solids by 57.2% and grease particularly has been reduced by 52.6%. Much of this has resulted from the institution of good housekeeping practice by industry itself. We feel that this has not only benefited the District but industry as well.

2. It has resulted in some decrease in the quantity of sewage contributed by industry. Management watches water consumption much more carefully.

3. The District has collected approximately $100,000 in each of the last two years from these surcharges and thus the parties who are contributing the higher strength are paying a proportionately higher cost for the extra work involved in treatment.

The District intends to continue this program until all industries have been completely investigated. In addition, it will be necessary to continue both the regular and spot sampling of the effluent from the various industries in order to make sure that the best possible job is done with the pre-treatment facilities installed, since it has been observed that only by continual vigilance on the part of both the District and top management of industry, can the best results be achieved.

Separate Sewered Areas — As mentioned, the original sewers constructed in this area were of the combined type. This resulted in the intercepting system being designed to intercept 2.75 times the average dry weather flow. Consequently, during periods of rain, the excess storm water mixed with some of the sewage passed on into the river untreated. While the District has been subject to periodic demands to prevent such spills, it was obvious that the cost to carry out such a program would be tremendous. As a matter of fact, a recent estimate indicated that it would cost at least $200 million merely to convey all of the combined sewage to the treatment plant.

It was however evident that ultimately additional treatment plants would be required and that these would have to provide secondary as well as primary treatment. Consequently, in line with modern practice, it was decided that the future development particularly of the upstream areas along the Red and Assiniboine rivers should be laid out on the basis of separate sewered system. Accordingly, By-Law No. 72 was passed in 1957 which gave the District the authority to designate areas to be served by a separate system of sewers. There was considerable objection to this on the grounds that these designated areas were being discriminated against in that the cost of providing sewers for them would be considerably higher than for the areas served by combined sewers. However, after making a detailed explanation to the municipalities concerned, the District was able to implement this program and all new upstream areas which will eventually be served by the new treatment plant have now been laid out and are being developed on the basis of a separate sewer system.

The District has felt however that those areas which are at present served by combined trunks but have not been fully developed in their upper reaches could be permitted to complete development on a combined sewer basis rather than insisting on separate sewers and providing additional storm trunks at very considerable extra cost. One or two sewer districts immediately adjacent to the plant have also been permitted to be developed on the combined sewer basis. While there are some who feel that we are not being consistent, the District's engineers do feel that it is both economically and practically justified.

Research.

Mark D. Hollis, President of the Water Pollution Control Federation, [1] who is also Assistant Surgeon and Chief Engineer of the U.S. Public Health Service, in a recent review of the progress made during 1959 detailed a number of problems in pollution control and made this observation on waste treatment research: "It is in the field of water pollution abatement research that the lag is greatest among all the elements that go to make up the problem of containing and reducing the contamination of the nation's Water Resource." The lack of research on this problem in Canada is even greater than it is in the United States and much more work on this subject should be done by our universities, by industry and in the treatment plants themselves, particularly in view of the fact that climatologically and for other reasons, Canadian problems are not necessarily the same as they are elsewhere. Furthermore, by doing this kind of research work, we will be able to develop our own sanitary engineers to the point where we will have adequate manpower to deal with these problems that lie before us.

The picture is not entirely black. Recently, the Ontario Water Resources Commission has completed a new research laboratory building in Toronto which should result in a considerable amount of research work being done. Some of the universities are undertaking research programs with grants from the National Research Council. It might therefore be of interest to record one or two experiments that the Sanitary District has been working on over these last few years.

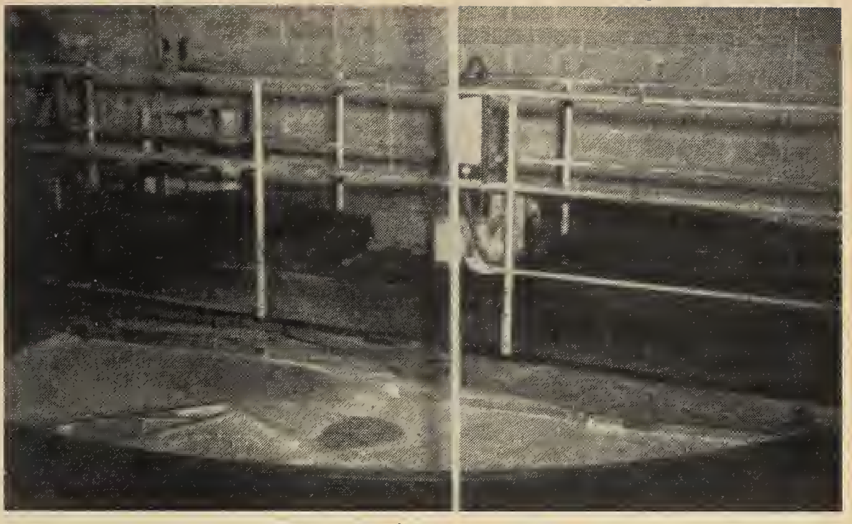


Fig. 3. Pacific Separator Unit

Sludge Handling.

One of the most difficult and costly problems in operating a sewage plant particularly in large communities, is the dewatering and ultimate disposal of the sludge. It is estimated that by 1965 we will have to dispose of some 12 million lb. of dry sludge solids with a volume of more than 15,000 cu. yds. per year. Since it costs the District about $16.60 per ton of solids to dewater its sludge by vacuum filtration we have naturally been on the lookout for more economical methods of sludge dewatering to reduce operating costs.

Various methods have been used for sludge disposal as follows:

1. Sludge has been disposed of by filling gulleys and depressions, and in excavations called lagoons specially dug for this purpose;

2. liquid sludge has been pumped into tanker trucks and spread over fields or pastures;

3. sludge has been dewatered by various means and then either burned, spread on land as a soil builder, or dried and sold as fertilizer.

The first two methods are only applicable to very small communities. Sludge incineration with subsequent disposal of ash is relatively expensive and has generally been used in comparatively large cities. There are a number of plants where sludge has been dried and sold for fertilizer, but in virtually none of these cases has it been an economic success and it has only been used if local conditions make disposal by other means impracticable. The most universal method is to dewater the sludge by various means and then spread it on land as a soil builder.

There are three general methods of dewatering sludge: Spreading on sand beds, placing it in lagoons and by mechanical dewatering equipment. The construction of sand beds is fairly expensive and is economically suitable for small installations where climatic conditions are favorable. Lagooning of sludge has been successful in a number of communities (we will refer to this later in this paper). In the case of mechanical equipment, the sludge is usually dried by means of vacuum filters of the drum type where the sludge is spread on a suitable membrane and a vacuum is applied thus reducing the water content to about 70% to 75%.

In order to dewater sludge by vacuum filtration, it is necessary to apply chemicals so as to obtain a floc. In Winnipeg, ferric chloride is used and is fairly expensive since it has to be shipped in tank cars from Eastern Canada or the United States. Therefore a preliminary step known as 'Elutriation' or washing of the sludge was provided to decrease its alkalinity and thus reduce the amount of chemical needed. However, despite this, the chemical cost has still been extremely high running, to about $8.00 per ton of dry solids for ferric chloride and lime with the new filter.

Consequently, when the extensions to the plant were being planned, our consultants recommended that the sludge be dewatered by lagooning. However, the District's engineers had some reservations about this method because of two factors: first, our relatively impermeable subsoil, and second, our climatic conditions which permit practically no evaporation during the winter months; as a matter of fact, our evaporation roughly balances our precipitation. As a result in 1950 it was decided to construct three and a half acres of test lagoons and to experiment with them for a period of time in order to determine how these would work out under our local conditions.

Experiments were conducted for a period of about three years and while this is a relatively short period of time upon which to make an absolute determination, indications were that under normal conditions of operation, it was practical and economical to lagoon sludge but that it would be advisable as an insurance measure to provide modern vacuum filtration equipment so as to give the plant a degree of flexibility which would enable it to operate under all possible conditions. [5,6]

Four large lagoons occupying some 20 acres were constructed and 65 acres of additional land were purchased adjacent to the plant for future construction of lagoons. These lagoons have now been in regular operation for some four years. Experience has shown that under normal conditions they will work very well and will dewater the sludge much more economically than is the case with elutriation and vacuum filtration. The cost for lagooning, excluding lagoon maintenance, is 96 cents per ton of dry solids as against $16.60 for vacuum filtered sludge..

The method of operation is to fill the lagoon with 10 in. of completely digested sludge, permit it to settle for about 14 days and then decant the surface liquor. This procedure is repeated until the lagoon is filled to the desired level. During the winter the sludge freezes, thus not permitting decanting until the following spring.

However, in order to empty the lagoons economically, it is necessary to use large 12 yd. scrapers and these can only be used effectively at certain times of the year after periods when there has not been any appreciable precipitation. This type of equipment is quite expensive and is almost invariably in use on road building during the summer, so it is not always possible to obtain it just at the time that it is best suited for easy removal of the sludge. For example, the rainfall during the summer of 1959 was very much above normal, and even more important, was spread more or less throughout the entire summer. Consequently, it was not possible to have the lagoons emptied before freeze-up.

A new method of emptying was therefore tried early this winter, after the sludge in the lagoons had frozen and equipment was easily available. The first step was to have a ripper pulled over the deposited sludge by a heavy lugged tractor. The 12 yd. scrapers then moved in and removed the sludge which had been ripped to a depth of 12 in. from the lagoon. Alternately using the ripper and the scrapers, it was possible to empty the lagoons very effectively at a relatively low cost working out to about $1.06 per ton of dry solids moved. The sludge was piled in the regular way and this spring if we find that it will be sufficiently dry to handle easily for spreading, then this will become the regular method of cleaning the lagoons and should prove very effective and economical.

The science of sewage treatment and disposal is in continual flux with new and improved processes being developed continually. Recently, two new processes of handling sludge have been developed. One of these known as the Atomized Suspension Technique (A.S.T.) was developed by the Pulp and Paper Research Institute of Canada. As the name implies, the sludge is atomized into small particles and is introduced into the top of a tall cylinder and oxidized as it falls to the bottom. Following pilot plant studies, a full scale plant installation has been constructed for the town of Beaconsfield, Quebec, close to Montreal.

The second process is known as the Zimmerman process and was developed by Sterling Drug Incorporated in the United States. This process uses the principle of wet oxidation which takes place when the sludge is introduced into a reactor operating under high pressure and temperature. Following pilot plant studies, at the Chicago Metropolitan Sanitary District, that Authority has awarded a contract for the construction of 4 50-ton units. Another contract has also been awarded in Wheeling, West Virginia, for 1 5.6-ton unit.

Both of these processes will be watched very carefully by all sewage treatment authorities to see whether any economies can be effected in sludge disposal by their use.

Secondary Treatment.

All Provincial Agencies responsible for the conservation of water resources and prevention of pollution have become increasingly aware of the urgency of this problem and have been taking steps to deal with the situation. In Manitoba, the Provincial Sanitary Control Commission several years ago, after considerable investigation, tabled an Outline of Policy in the Legislature, which will govern and control the discharge of sewage and wastes into bodies of water in the Province and will therefore determine the degree of sewage treatment required. The following are excerpts from this statement. "The proposed policy recognizes that all bodies of water in Manitoba are an important natural resource of the Province and the need to conserve and utilize the inherent advantage and value of these bodies of water without unreasonable restriction, but with due regard to the needs and requirements of the Public at large, of organized municipalities and of industry and Commerce . . . the proposed policy also takes into account the desirability within practical limits, of protecting these bodies of water so that the normal features of aesthetic qualities, habitat for fish and wild fowl, recreational facilities and drainage works, suffer a minimum impairment", and "the Commission feels that the application of Policy must be based on the premises that any body of water may be necessarily subject to some degree of contamination or pollution" (that is, it is impracticable to always retain the so-called pure condition).

Since the stretch of the Red River immediately downstream from the plant has been zoned as a recovery zone it would indicate that the Dis-

Fig. 4. Effluent end of manure settling tanks and the flow measuring and sampling equipment

Fig. 5. A.P.I. Oil Separator

Fig. 6. Oxidation Pond

trict's initially adopted policy, whereby only primary treatment was provided with the rivers natural dilution properties being used to take care of the primary effluent, will fit in with the Provincial Government's policy. It has nevertheless become increasingly clear that we are approaching the maximum load which can safely be imposed on the river without the danger of creating a nuisance. Furthermore, we must also recognize the fact that standards are tending to become higher and that consideration will therefore have to be given the eventual installation of some degree of secondary treatment at the present plant. The new plant to be constructed will of course include secondary treatment.

For both of these considerations, the District has been carefully watching the extensive use of sewage lagoons which has developed during the last number of years in both the Dakotas of the United States and in the Prairie Provinces. While all of these have apparently worked very satisfactorily, and have done a reasonably thorough job, economically and simply, most of the installations have served relatively small populations. The City of Regina will now probably be using the largest sewage lagoons constructed anywhere.

In order to make them applicable to larger communities, heavier loadings would have to be practicable. So far, there is not sufficient data on the exact loadings, particularly heavier loadings that can be successfully placed in sewage lagoons under controlled conditions in our northern climate. The District therefore last year conducted some initial experiments on the use of lagoons for the treatment of its primary effluent. In these experiments, the lagoons used initially for experimenting on sludge dewatering, already mentioned, were utilized. It is proposed to undertake some further studies this coming year in conjunction with the Provincial Department of Health and Public Welfare. It will be interesting to see what results will come from these experiments particularly under our local conditions.

Conclusion.

Earlier, a statement was quoted from a recent review by Dr. Mark D. Hollis. I would like to refer again to this review in which he states that "while Cities alone in the United States were now spendng at a $400 million per year rate level for new or improved wastes treatment plants . . . this is still below the 'break-even' level considering the growth of sewered population, the War back-log and obsolescence." While in most parts of Canada, we have been blessed with tremendous water resources, it has become increasingly clear that they also are becoming depleted and grossly polluted and we have no reasons to believe that the situation in Canada in regard to conservation and pollution control is any better than in the United States. There are signs however that various forward thinking groups throughout the Country are becoming aware of this problem and that certain action is being taken to try and remedy these conditions. To mention a few of these — the establishment of the Ontario Water Resources Commission, several years ago, and the tremendous amount of work that has already been accomplished by this recently created body; the Quebec Legislature at its recent session appropriated $25 million for pollution control and water conservation; and the Canadian Institute on Sewage and Sanitation at its Annual Meeting last October passed the following resolution on September 29th, 1959.

"1. Water pollution must be recognized as one of the major national problems of the day, affecting the environment, health, and welfare of all citizens of Canada.

2. The Institute, in support of its objective for clean streams pays tribute to the effective work being done by many agencies in this field and urges an intensification of this campaign by all citizens, and all groups interested in health protection, conservation of natural resources, safeguarding of recreational facilities, preservation of fish and wildlife, and the maintenance of a beneficial environment.

3. The Institute is confident that if the pollution abatement program is carried out aggressively our lakes and streams and tidal waters can be restored to and maintained in a condition which will ensure that they can be enjoyed by all citizens and can be utilized for all the many purposes for which our natural resources were intended."

This resolution was circulated among all interested bodies including the three levels of Government.

While this indicates that the trend is in the right direction, we must nevertheless regard this as but a beginning. Much remains to be done and it is to be hoped that we can profit by the experience of the pollution control bodies in the United States and move quickly, since the old saying that "an once of prevention is worth more than a pound of cure" definitely applies to water conservation. The Greater Winnipeg Sanitary District like other similar agencies in Canada, looks forward to playing a continuing role in this national problem.

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ADVANCES IN SEWAGE AND WASTE TREATMENT

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Efforts at pollution abatement in water supplies have been increasing in recent years. Construction programs have gathered momentum in Canada as in most countries. Pollution is now recognized as a national and world-wide problem. It is essential that steps be taken to make control measures effective. It is only in this way that water resources can be conserved for the many uses for which they were intended. In these programs, involving high expenditures, critical analyses must be made of methods utilized in waste treatment. This is necessary if the most effective results are to be assured and the most economical solution obtained.

AN APPRECIATION of the objectives in sewage treatment is desirable at the outset. What degree of treatment is necessary, what are the methods in use, and what are the basic principles in these methods? It is desirable to know the nature of sewage and other wastes and the effects these may have on the receiving streams or watercourses. What are the limits to which treatment can go in removing substances found even in minute quantities? How can costs be altered through the design of the treatment works, either the capital costs or operating charges? Should industrial wastes be treated with domestic sewage in the one plant or is it preferable to keep them separate, and what is the result in each instance? These and many other questions come to the fore. What is revealed when an examination is made of the advances that have taken place in this field over the years? More important probably, will be the advances which can be expected in the future, and how the past developments have influenced these. It is obviously not feasible to discuss all details of the progress made in treatment processes. That is a very large field, but it is possible to examine some of the general principles involved in these forward steps.

In sewage treatment, as in most engineering problems, cost must always be given close attention. There are many measures which can be used if cost is not a serious factor. When something like $50 per capita may be involved to build a sewage treatment plant of the secondary type the designer must examine closely all measures which can reduce this cost without detracting from the results he sets out to achieve. The research laboratory and the developer need to direct their efforts at improving existing measures and developing new ones which will aim at economy. In a program of waste disposal many branches of science can contribute. Hence there is need for a co-ordinated approach by many towards both better and simpler methods, and particularly to a reduction in costs.

What Can Treatment Works Accomplish

Sewage and waste purification works can accomplish a great deal. There are also many things they do not overcome in regular treatment. There is a good deal of flexibility in the designs used, depending on what degree of processing is needed. Sewage coming from urban communities is a complex mixture chiefly because it is not merely the domestic wastes from houses and offices, but it contains a high proportion of industrial wastes and substances from many sources. It is common to state that sanitary sewage should contain about 0.20 lb. of suspended solids per capita and 0.17 lb. of B.O.D. (Biochemical Oxygen Demand). This would be in order except that some systems receive much industrial waste while others have little. Some wastes have much organic matter and a high B.O.D. figure. Others have constituents not measured in the normal tests. A variety of chemical wastes may be present, some of which may, even if in only small quantities, travel long distances in a stream. Some are toxic, some produce obnoxious tastes, some carry oil, others may be strongly acid or alkaline, while some carry floating material such as feathers, garbage, or finely divided substances which do not respond readily to the usual treatment processes, and some contain valuable fertilizers for plant growth.

It would be unrealistic to think that the sewage treatment plant should be designed to remove or nullify all of these substances. For one reason, the cost would be very high. The question arises as to whether industrial wastes should be treated with the municipal sewage or be dealt with separately. Some wastes readily respond to the same treatment as sewage, and a joint plant has advantages. In other cases it is preferable to consider treatment of the industrial waste separately where the specific ingredients can be attacked. There is thus no rule that will apply in all cases.

The modern sewage purification plant when designed for full treatment is an effective device. It can remove organic matter as measured by the B.O.D. test from about 300 p.p.m. to 10 p.p.m. or less. A similar reduction can be made for suspended solids. The bacterial content, measured by the coliform test, is reduced in the biological processes, and when chorine is applied to the effluent the reduction in coliform can be almost complete. Thus measured in these terms a sewage treatment plant accomplishes a great deal and converts a heavily laden raw sewage to a clear, odourless water with a low bacterial content. Whether the purification is to go this far will depend on local requirements. In bringing about specific results the plant is designed to fit the local conditions.

Treatment of sewage or industrial waste must be designed to safeguard the watercourse against undue pollution. The final test is not so much the quality of the effluent but the effect on the stream after initial dilution has taken place. The use of that stream will have an important relationship to the degree of purification needed. The volume of water in the stream is a significant factor. The flow of water in the Great Lakes System gives a high dilution for any effluent, and when the water is flowing as in a river there is a continuous mixing and removal. Discharge into a lake may tend to concentrate the effluent at the end of the outfall when the water is quiescent.

Local requirements may place a heavy or a light burden on the treatment processes. The cost will be affected directly. The designer must be prepared to incorporate in the works whatever is needed to satisfy local conditions. He can design for a degree of treatment that will permit the effluent to be discharged satisfactorily in a watercourse with little or no water at times. In the light of these stringent requirements and wide variations it is essential that every true advance be utilized and that there be a co-ordinated effort to seek out the best and most economical means for this purpose.

The stream or lake receiving wastes, either raw or treated, responds to that load and natural purification processes are constantly at work, sometimes more actively than at others. The result may be that organic matter will be reduced readily by the oxygen in the water, the supply of which will be restored from the air and plant growth. Bacteria tend to die out in the water, an unnatural habitat. But other substances may travel long distances in a stream or remain active for a long period in a lake. Chemical substances may travel several hundred miles before their effects are reduced to insignificant amounts. Phenol, as a potent taste substance in water, may likewise travel great distances, and even small amounts as low as one part in a billion may be objectionable in drinking water. Oils and many other substances have disastrous effects on the stream. The great increase in the use of chemical substances such as synthetic detergents, pesticides, weedicides and others, may result in these being carried into the streams and their effects being felt in a variety of ways.

Treatment Processes in Use

The fundamental processes in sewage treatment have been utilized for many years. Important changes have been made in the application of these methods, but the principles have not changed radically. They include physical measures as in screening, sedimentation, flotation, and transportation of materials; biological processes as in sand filtration, trickling filters, activated sludge systems, sludge digestion, lagoons or stabilization ponds, and miscellaneous aerobic methods; chemical treatment as in flocculation and disinfection. These make up the main measures employed in removing the objectionable ingredients from sewage and other liquid wastes. Many modifications of these measures have been instituted and many more can be expected in an effort to assist the basic processes and thereby to shorten the treatment time, increase efficiency, and reduce costs. These advances made over the years are important in meeting the objectives for clean streams and conservation of our national water resources.

The treatment of sewage and industrial wastes readily separates into two parts, one the treatment of the liquid to discharge an innocuous effluent, the other to dispose of the solids or sludge removed in the process.

It may be noted that these advances, now in progress or expected in the future, should not delay the initiation of works any more than the hope for new developments in motor cars, TV, and so many other products should postpone purchases. Public reaction, particularly where there is a desire to delay expenditures, is to wait for new developments. Another extreme view is to assume that advances are not taking place and new measures should not be accepted. Neither of these attitudes favours the cause of sewage treatment. The engineer must choose what may be regarded as a middle course. He must be prepared to design a plant now which will give the desired results. He should incorporate in his design new advances which offer a reasonable chance for success. He cannot risk his professional reputation and gamble with his client's money by specifying something which is not proven. This decision is no easy task, especially when he is confronted with many so-called advances aimed at economy and efficiency. These processes have been numerous in the past, but the mortality rate among them has been high because either they were not proven or other advances made them of less value. Some measures have been quite successful under certain conditions, but not acceptable for others. It thus becomes an important responsibility for the engineer to serve his client effectively by choosing methods and facilities which are modern and economical, but not before these have been tried enough to offer an opportunity for success. The earlier methods, in most respects, were capable of producing a good effluent and obtaining the necessary results, but the means and the cost are considerations which must be examined critically at all times.

What Are The Advances

A review of some of the more significant advances in sewage and waste treatment of the past can aid in assessing what is important now or what the trend may be in the future. It is not feasible to describe in detail these various steps, but certain general principles may be sufficient for the purpose. They can be considered under the broad headings of physical processes, biological treatment, and chemical treatment.

The Physical Processes

Physical processes have been used widely in sewage purification. They remove solids by screening, sedimentation, or flotation. They involve the

Fig. 1 Primary clarifiers at Brantford's new sewage treatment plant. Sludge digesters are in the background.

transportation of the liquids and sludge from place to place and provide other useful work about the plant. They are inter-related to the biological processes, and the two work jointly to attain the same objective. Physical processes are usually cheaper than biological measures. Primary or partial treatment is nearly all due to physical forces.

The opportunity for improvement in physical processes is attested to by the great changes made over a period of years. Mechanization of these methods has greatly changed the operation of sewage works. This process thus keeps pace with similar trends in other fields. While these improvements may not change the quality of the plant effluent to any great degree they accomplish much easier operation and greater convenience.

Some of the improvements which have taken place from earlier days are seen in the mechanical cleaning of screens, thereby permitting smaller openings, the more widespread use of fine screens, grinding of screenings for return to the sewage and consequent ease of handling, mechanical removal of settled grit and the washing of organic material from grit, and the use of mechanically cleaned sedimentation tanks for primary treatment and in conjunction with secondary treatment — all aimed at improved convenience and ease of operation.

Important advances to date in the physical processes have resulted in the widespread application of improved settling efficiencies in mechanically cleaned tanks, and in ways to remove the settled sludge continuously and with little inconvenience. Much has been done to provide better

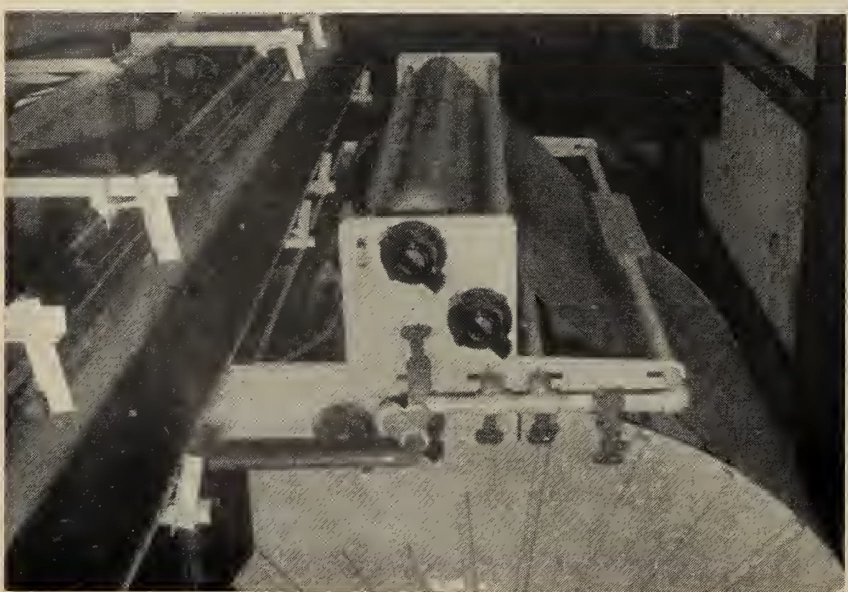
Fig. 2 Air Compressors in the main pumphouse in Stratford's OWRC-built and operated sewage treatment plant which was opened in 1958.

and more correctly spaced overflow weirs, and improved inlet and outlet arrangements for the tanks. Studies have been made on the effects of these on tank performance with the result that the designer has information to permit the best arrangement for these tanks. It can be considered that in sedimentation performance the advances have been directed to improved efficiency in solids removal and convenience of operation. Further efforts in this same general direction can be expected. Most settling tanks are now mechanically equipped, and they provide good results.

Flotation as a physical process acts in reverse to sedimentation, and the solids are floated to the surface entrained in air bubbles. While this is not widely used in sewage treatment it has promising results in certain industrial wastes. The opportunity for removing the solids in this fashion offers efficiency and economy. This is an advance of recent years, and more efforts can be expected.

Grit removal involves careful design of the units as well as effective measures for moving this material from the tanks. Various ways can be used. A further action is the washing of the grit free of organic material. Progress has been made in this with the result that the final product can be deposited almost anywhere without fear of odours or offensive conditions. Much of the advance made in this part of sewage treatment has to do with transportation and washing for convenient and economical disposal.

Fig. 3 A feature of Brantford's new sewage treatment plant is a vacuum filter designed to reduce the moisture content of sludge. The plant was built by and is being operated by the Ontario Water Resources Commission.



The Biological Processes

Sewage purification has always relied on biological processes for secondary or full treatment. They are subject to all the vagaries of bacterial action. So long as this condition prevails the efforts to bring improvements will be directed to assisting these natural agencies, by creating environments in which the processes can proceed rapidly. The steady progress through such methods as sand filtration contact filters, trickling filters, activated sludge, oxidation ponds, and other aerobic methods attest to the efforts made to reach this objective. Rapid oxidation with high purification at minimum cost has been the search over the years. Great improvements have been made, but only general principles can be reviewed at this time.

Automation

Automation has been used in ever increasing ways in sewage treatment. This has offered a wide scope for the engineer and manufacturer. It promises better control of the essential processes and removal of the weakness of the personal element. Automation goes hand in hand with mechanization, and it can be expected that further advances will be made in this direction.

Sludge Disposal

After treatment of the sewage or waste there remains the difficult problem of disposal of the solids or sludge. This has grown to be a major feature of the overall requirements of reducing these residues to something which no longer is dangerous or offensive. Sludge disposal has gone through many changes and the end is not in sight. The efforts of many have been concentrated on this solution.

Sludge being largely organic and subject to decomposition can produce highly offensive odours. The objective is therefore to prevent the escape of odours while at the same time permitting the rapid break-down of organic material at a minimum of cost. The final product must be disposable by piling or put to a useful purpose.

Sludge digestion, so widely used for many years, was a development of the anaerobic process at work in the early septic tanks. Steps were taken to provide the maximum adjustment of the biological environment such as heat and foods. Considerable cost is involved in sludge digestion and in dewatering the resulting solids. The break-down of organics in digestion is relatively slow. Efforts at improvement have concentrated speeding up the process or by-passing this for other measures, and reducing both capital and operating costs.

Sludge disposal is still a real problem, not so much in attaining a satisfactory end product but in improving efficiency and economy. Omission of the digestion process can eliminate the capital costs for these tanks. It is necessary to balance this improvement against the condition of the final product and the annual overall savings.

Dewatering of sludge has been an outstanding difficulty. Open sludge drying beds can result in slow drying, odours and higher labour costs. They are not favoured now. Vacuum filters for dewatering of either digested or raw sludge have gone through many changes. They call for conditioning of the sludge with chemicals, and the control of costs is an important element.

At present a number of other methods for sludge disposal are receiving attention. The dewatering of raw sludge on vacuum filters with sufficient chemicals to prevent odour problems is one approach used in a number of works. Another method employs a rotating filter made of nylon fabric and not requiring chemical conditioning. Still another aims at removal of the water content by sonic or high frequency vibrations. No chemicals are involved.

A recent development in Canada, the atomized suspension technique, embodies different principles. The raw sludge is thickened to about 10% to 12% solids and then sprayed through a nozzle into a chamber heated by electricity or gas. The sludge can be dried or burned at a high enough temperature to avoid odours. One plant is in operation at Beaconsfield, P.Q.

Sludge incineration has been used for many years with satisfactory results. Improvements have been consistent in this method.

The newer or modified methods for sludge disposal must be considered in respect to accomplishment of objectives and assurance of trouble free operation at competitive costs. Any new process requires a period of trial under different conditions to overcome possible defects and to determine costs. It can be expected that the search for the ideal sludge disposal process will continue and that further advances will follow.

Disinfection and Polishing Effluents

Sewage effluents must be discharged sometimes under stringent conditions such as low diluting water, proximity to water intakes or bathing beaches. Further improvements in the effluent may then be necessary. Efforts have been made to polish the liquid by the use of sand filters, and more recently by the use of micro strainers. Improvements are possible in these ways.

Disinfection of effluents is increasing after the practice established in water treatment. In this way the bacterial content can be greatly reduced and other benefits derived. As the trend towards better effluents moves along more use can be expected of disinfecting processes.

Single vs. Multiple Plants

Another advance in sewage treatment has been obtained by using larger plants rather than a number of small ones. This involves no new or different process but rather an opportunity for operating efficiency and lower costs. A small plant can, if properly designed, produce an effluent equal to that of the large unit, but it may not receive the same supervision given at a large plant where trained and capable operators are in charge.

Industrial Processes

Industrial waste treatment processes are numerous. The advances made in these have kept pace with the progress in sewage treatment. Discussion of all these is not feasible. Some of the methods are the same as for sewage, while others depart widely. The changing composition of industrial wastes calls for appropriate measures to meet each new situation.

Summary and Conclusions

Sewage and waste purification has been subjected to many developments, all leading to the objective of high efficiency, well purified effluents, and low cost. Physical processes, biological treatment, and disinfection have all moved steadily forward towards the desired goal. In spite of the improvements there is still much more that can be expected. The need for treatment of sewage and industrial wastes is aggravated by concentration of population in urban centres and by industrial expansion with its great variety of complex wastes. Concentrated research and study of different methods will be needed. The designer of treatment facilities should have access to methods which can be used with confidence to attain the desired results under many different circumstances.

Fig. 4 The Streetsville plant built by the OWRC is a good example of a small plant producing a clear effluent.

THE ONTARIO PLAN FOR WATER POLLUTION CONTROL

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Conservation, with the best use of national resources, is an obligation resting upon every country. Water must be recognized as a major resource, without which little progress can be made in growth or human betterment. Some parts of the world have abundant water supplies, others are confronted with frustrating shortages. In either case it is imperative that the importance of adequate water supplies be recognized, and that appropriate action be taken to safeguard these waters against abuse. Since the quantity of water in the world remains constant it only changes in quality and in local distribution. The use of these waters to the best advantage for all normal requirements must be the common objective.

THE REPEATED use of water in its journey from rainfall to the sea becomes ever more necessary as populations increase and concentrate in urban centres, and as industry expands. The great deterrent to this maximum use comes from pollution. This can change the water to a damaged, useless resource until the purifying processes of nature restore its quality. Long periods of time and great distances of travel may be required for this restoration. Further pollution may be added along the route with the result that the water continues to be unsuitable for those along the course of travel. In this situation the country's best resource is dissipated and progress fails or is adversely affected.

The Problems of Water Pollution

What are today's problems of water pollution and how can these be kept under control? Are these difficulties greater than in the past, and are remedial measures worthwhile and within the reach of all? Water pollution has always created problems even from the earliest habitation of this country. The situation has deteriorated as communities grew and as industrial wastes became more complex and larger in volume. The time has now come when there is a realization that this national resource must be utilized for the benefit of all. No country can afford the high cost of continuing neglect of pollution control. The means for meeting the situation are feasible and ready to be put into service. The "Ontario Plan" is one approach to this problem. It is now going forward with gratifying success.

Canada, like other countries, has neglected its water resources. The depression years and the war period pushed the normal program into the background. The problem of catching up on this backlog would be great enough, but it has been magnified by the concentration of population in urban centres, which makes it difficult even to hold a balance and not slip farther back. In the same period industry has expanded tremendously in this country. Even more significant are the complex nature of the wastes and the frequent changes in these. To these problems must be added the greatly increased costs for treatment facilities. It is not unexpected that these conditions would create in the minds of the public a desire to defer action on projects which seldom have much public appeal. Against this background must be brought into sharp focus the value of our water resources and the price to be paid if we fail to take aggressive action.

Factors contributing to the pollution problem in the United States are well presented in a statement on hearings on environmental health problems. It can readily be visualized what may follow in Canada as growth continues. The statement contains the following:

"When in the space of fifty years you more than double the population, concentrate two-thirds of it in urban communities, increase the number of automobile vehicles, from about 1,000 to 70 million, and multiply total industrial production by 900%, you are bound to have entirely new environmental problems. Some of the figures of our chemical environment are really astounding. There are more than 500,000 distinct chemical compounds in use in industrial production today, while twenty years ago there were only a few hundred. In addition, they say, upward of 10,000 new compounds are being developed in laboratories each year, and a substantial number of these are put to use. Even more startling figures — unknown billions of tons of wastes are discharged each year into the rivers and streams which provide drinking water for most of the population."

Canada has not yet reached the magnitude of the United States in population and industry, but the problems are not unlike. There is need for prompt action.

Action on Water Resources Eleswhere

It is worthy of note that pollution control is being given a high priority in other countries as well. This is a recognition of the importance of water resources as a key link in that chain of factors responsible for national welfare and growth. Presidential Committees in the United States, composed of eminent men, have given intensive study to their water resources and the programs necessary to protect these for the future. Similarly in Great Britain there is an acute awareness of the priority which must be given to adequate water supplies, both for industry and municipal needs. Without this, there is no freedom in the selection of sites for industry or in the opportunity to expand. Similar emphasis is placed on this problem in most places in the world, so that it may be truly said today there is a greater recognition of the importance of water resources than ever before.

The Ontario Plan

In Ontario, a plan has been developed which gives full recognition to the protection of water resources. It makes it possible to distribute water to wherever it may be needed, and, an important feature, it provides for protection of existing sources of supply against pollution. In this way maximum use can be made of all water resources rather than permitting them to be damaged and rendered useless for much of the time.

The Ontario Plan resulted from the appointment by the Government in 1955 of a committee to study water resources and supply. In the following year legislation was passed to appoint a Commission. The Ontario Water Resources Commission Act came into being in 1957, and it remains in effect today with some amendments. Some unique features are included in this legislation and in the administration of the program. This action was taken when it was clear that water resources must play an important role in the future well-being and progress of the Province.

The Ontario Water Resources Commission

In broad terms the program of the Commission may be divided into two fields: one to exercise supervision over water supplies, sewage works, and industrial wastes in the Province. Water pollution control forms an important part of this. The other is to design, construct, finance, and operate water and sewage works for municipalities and others. Some related activities to these two major fields are included in the program.

Through this new Act the supervision over water and sewage works and control of pollution now comes under the Commission. This function was formerly administered by the Provincial Department of Health, as it still is in most other provinces. This adminstrative change is especially significant insofar as water pollution is concerned. The Act now gives wide powers to deal with stream sanitation. It is not limited to those conditions which may adversely affect public health, but covers any condition which may impair the quality of the receiving watercourse. It is no longer restricted to bacterial contaminants, but extends to all forms of pollution. It includes such substances as silt from gravel washing operations, oil wastes, and chemical deposits, even though these may be of no significance in the transmission of disease. This is a different approach to an age-old pollution problem. The necessity is clear when it is recognized that one of the most difficult pollution problems today comes from industrial wastes, some of which are present only in minute quantities but which substances are continuously changing. Industrial expansion in this Province and growth of urban communities will add further to the need for adequate means of pollution abatement, as has been shown in the United States.

The Construction Program

The Commission, at an early date, adopted water quality objectives for stream sanitation. When this is combined with legislative authority for enforcement, it can form an important part of a desirable overall program. This alone is not adequate. There must be means for aiding the municipalities and for ensuring that the required works can be financed. In the Ontario Plan the Commission is authorized to enter into agreements with municipalities for providing funds and for carrying out the complete program. This does not involve cash grants, but it utilizes the credit of the Province to supply the funds and the technical staff to assist the municipalities in these complex projects. There is thus an effort to bring the maximum assistance to the municipalities in meeting their requirements for pollution control. Industry must also meet its obligation to provide adequate treatment of all wastes and to preserve the purity of the water resources.

Organization of Commission

The Water Resources Commission is composed at present of six members from different parts of the Province. The Commission's activities are organized into the divisions of Administration, Construction, Plant Operations, Sanitary Engineering, Laboratories and Research, and Water Resources. All are co-ordinated to attack best the various problems. A staff of

Fig. 1. Aeration tanks at the new activated sludge plant at Stratford designed to protect the Avon River.

technically trained personnel in these various fields has been recruited. A new and modern laboratory has been opened recently in the Toronto area. Here it is possible to make the various analyses needed for the Commission's program and to conduct research on current problems.

Accomplishments to Date

While the program of the Commission is still much in its infancy the accomplishments to date may be of interest, especially in dealing with water pollution. Some of these may be listed:

1. The unique feature of constructing water and sewage works for municipalities has progressed rapidly. There are now 113 of these projects involving an expenditure of over $48 million of which $34 million is for 53 sewage projects and $14 million for 60 water projects. Forty-eight of these projects are now in operation, and many more will be completed in the next few months. These will mean much towards pollution abatement;

2. It is gratifying to observe that at present nearly all the major municipalities are embarking on sewage treatment programs. At the same time there are programs for treatment of industrial wastes;

3. Stream pollution surveys have been carried out on a wide scale as a means for locating and correcting sources of pollution. Last year nearly 4,000 samples were collected in these surveys;

4. The Commission has just put into service a new and modern laboratory and research building. This will be an important aid in maintaining pollution control. The opportunities for research in this field are fully recognized in the building;

5. The contribution of the laboratory in the Commission's program may be seen in some measure by the fact that last year over 60,000 chemical analyses were made and over 9,000 bacteriological samples were examined;

6. The staff of the Commission has grown from about 25 in 1957 to over 180 at present, and over 70 operators of plants are now serving. Expert technical skills are being developed to give the most effective service in this program.

These accomplishments reveal something of the measures being taken to control water pollution. It is a province-wide campaign aimed at all centres and at all sources of pollution. The program is of great magnitude and involves high expenditures. Some parts of it will take a long time, but the important feature is that the program is in effect and that major advances have already been made.

Status of Pollution

The extent of the problem of pollution abatement in Ontario and its present status can be seen by a review of conditions in certain parts of the Province. In undertaking this assignment to control pollution it was apparent that surveys of sources of pollution and stream conditions must go on continuously. These must deal with domestic sewage, industrial wastes, and all other substances which may impair any of the water resources. Thus the laboratory becomes an important ally for the engineer and the technician engaged in this work. Acceptable standards or objectives must be set up as the goal to be reached.

Planning these surveys calls for a unit upon which to act. This may be done on a watershed basis or on a unit of local government such as the county or municipality. There are advantages to each. The watershed can be used to check all pollution entering a stream and to determine the effects of this on the quality of the water at different points in that watercourse. There is a defect in this method in that the stream may involve several different municipal governments, and when remedial action is being taken there is more difficulty in getting a unified approach. If the county is used as a basis of the survey and report it has administrative advantages. Similarly if the problem concerns only one municipality as in the case of a small lake or short stream, this can be used to advantage to report the findings.

The Ontario Water Resources Commission utilizes both of the above methods in carrying out its surveys, depending on local conditions. It has been found that a county survey brings better opportunities for all municipalities to act together. Even though the County Council may not be directly involved in the remedial measures there is an interest in bringing about good stream sanitation. Since a county is a relatively large area it may contain a good part of the watershed. Several county surveys have been completed to detect all sources of pollution. Once this is done steps are taken to see that all wastes are adequately treated before they reach the stream or other outlet. These surveys bring to light drains and pollution upon which there was little information. They include private outfalls direct to the stream as well as connections to storm drains. This problem is acute in those municipalities where no sanitary sewers have been installed, but where storm drains or open ditches exist. There is little tendency in the built-up sections of these unsewered communities to control connections to the storm drains or plumbing in general. In many places there is so little land that property owners find great difficulty in disposing of wastes except by making connections to storm drains. Conditions at the outlets of these drains invariably are offensive. Consequently, the construction of sanitary sewers should be undertaken as soon as finances will permit.

At the present time there are 976 incorporated municipalities in Ontario. They are composed of 575 townships, 154 villages, 158 towns, 30 cities, as well as 38 counties, 20 municipal Improvement Districts, and Metropolitan Toronto. The installation of sanitary sewers is not often undertaken in a community unless the population approaches one thousand or more. Accordingly, the cities, towns, and villages are the centres in which sewage works are most commonly built. Parts of townships may also be considered as urban centres, and the need for sewage works becomes apparent in these.

At present 246 public sewage works are in operation in Ontario, giving service to about 65% of the total population of the Province. This may be compared to 419 water works systems serving 69% of the total population. It is gratifying that action to provide sewage works in the smaller centres is proceeding at a good rate. This will do much to assist in pollution control throughout the Province.

The advances made in sewage purification plant construction along the major streams of the Province will make an important contribution to pollution removal. The Grand River, with concentrated industry and urban centres, is well along on this clean-up. Sewage treatment plants will give secondary treatment to all sewage, while industrial wastes will meet similar standards. Other streams such as the Credit River, Ottawa River, Thames River, and many smaller ones are making progress to deal with their pollution problems. Municipalities fronting on lakes are actively engaged in similar programs. The objective is a high degree of purification in all places, and sufficient in any event to ensure good quality water in the receiving streams, both as to bacteria and those constituents which tend to abstract oxygen from the stream or to impair its quality.

A number of large centres of population, most of which are located on

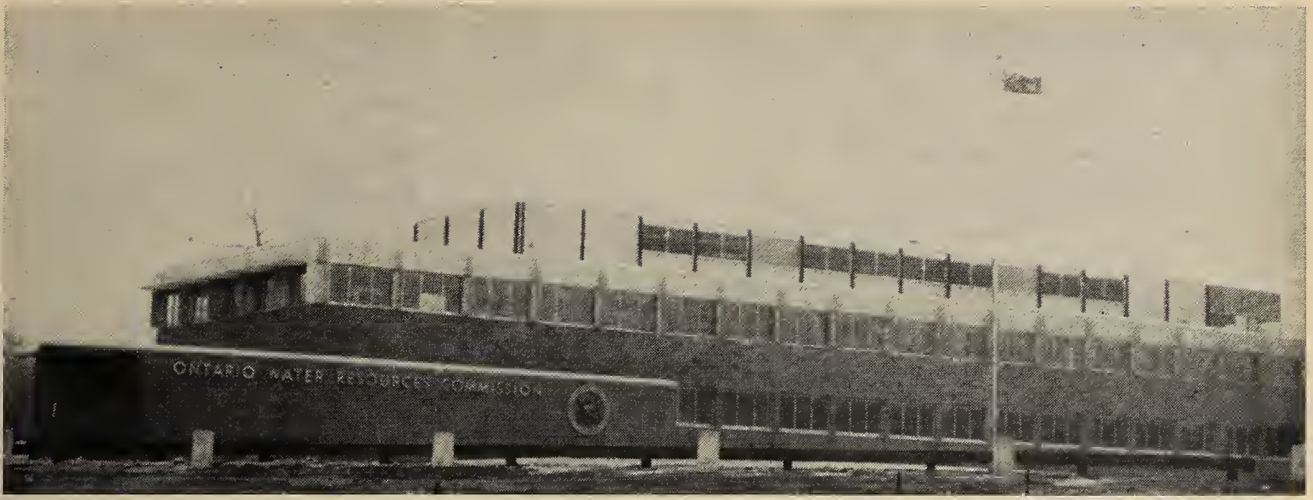

Fig. 2. New modern laboratory and research station.

large bodies of water, had delayed action on sewage treatment and had relied on dilution either alone or to supplement partial purification plants. The adoption of programs of sewage treatment in these places is a highlight of the program of the Commission. These include Port Arthur, Fort William, Sault Ste. Marie, Sarnia, Windsor, Niagara Falls, Hamilton, Toronto, Cornwall, Ottawa and others. The programs are in different stages, but it is possible to look forward with confidence to an early completion of these works.

The selection of design for works and the degree of purification of sewage must be related to local conditions. Where there is high dilution and no direct contact with water supplies or bathing beaches use may be made of the diluting water to aid in the purification of the sewage or industrial wastes. The objectives for water quality prescribed by the Commission recognize this feature. These objectives set the standard to be attained in the stream itself. In general it can be taken that the trend to higher purification of wastes is in effect regardless of the receiving watercourse. Where effluents must go to streams of low flow there is no alternative to a high degree of purification. Fortunately this can be attained in modern treatment works where physical, biological and chemical disinfection can produce an effluent of almost any desired quality.

Boundary Waters

The boundary waters between Canada and the United States are an asset of great importance. The two countries, acting under an early treaty, have entrusted the investigation of these waters to the International Joint Commission. References have been given by the two countries to study the waters and keep them under surveillance. Since most of these involve the Province of Ontario the work has been a joint effort on the part of the International Joint Commission and the Ontario Water Resources Commission. Much has been accomplished, and the program in effect is aimed at safeguarding these great water resources for their many uses in both countries.

The Industrial Waste Program

Industrial wastes are increasing in volume and complexity as the Province grows. Great changes have taken place in the part played by the wastes of industry in water pollution. Ontario has become a major industrial centre, with wastes of all kinds resulting from these operations. Much of the waste is accepted into the public sewers for disposal with the domestic sewage. Part of it goes into streams through private outfalls. The great variety and composition of wastes calls for many kinds of treatment. The fact that the wastes change frequently as new processes are developed adds further complications. Some of the troublesome industrial wastes come from pulp and paper plants, milk plants, packing plants, canning factories, metal plating industries, tanneries, oil refineries, chemical industries and others. Some industries produce wastes which have a highly objectionable effect on a stream, a condition which may travel several hundred miles before the effects are dissipated.

The Ontario plan for pollution control requires that industrial wastes be controlled in the same manner as municipal sewage. Treatment of both must go forward at the same time and to a sufficient degree to offset objectionable conditions in the stream. The facilities of the Commission are available to industry to assist in solving these waste problems. Research is an important tool in dealing with waste disposal and especially is this the case with industrial wastes. The Commission encourages industries of the same kind to organize and to work co-operatively in solving these problems. The new laboratory and research building of the Commission will enable the technical staff to co-operate with industry and attack these problems with a good expectation of success. Efforts in this direction are an integral part of the Ontario Plan.

Operation of Treatment Facilities

The mere construction of sewage and waste treatment plants is not a complete answer to the protection of stream quality. These will be ineffective if they are not operated intelligently. The Commission's program includes supervision over the operation of all these facilities in the Province. The objective is to ensure the results intended when the plant was designed. In those projects which the Commission builds, operations will be directly under its control. Full use will be made of the technical skill of the staff and the laboratory facilities. The responsibility for the results will then rest with the Commission.

Summary and Conclusions

In summary it is well to emphasize that water pollution is a problem of great magnitude. If uncontrolled, it can have disastrous effects on the water resources of the country and the well-being of the citizens. It must be considered as a serious economic factor in our national welfare, and something which calls for the best efforts of all. The Ontario Plan has been devised to attack pollution wherever it may be found, and to provide the best possible facilities for applying remedial measures. The results so far obtained are most encouraging. Efforts are being continued at an accelerated rate to provide clean waters everywhere in the Province.

ASPECTS OF RIVER POLLUTION IN THE PROVINCE OF QUEBEC

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Today we are making more demands upon our most valuable servant than ever before. In our homes, water has many functions, old and new. Water turns the wheels of mighty hydro-electric plants that furnish light and power for our industries. And most of the power not created by moving water is created by water in another form, steam. We use water to carry away the wastes from our homes, cities and industries. This use has always been important; today, it is threatening to cut down or prevent our other uses. The beauty of the landscape it creates, the fish and wildlife it supports, the fun of swimming and boating, all these give us pleasure and make it possible for us to return to our everyday lives refreshed and renewed. Water falls upon the earth, runs its life-giving course, and then is drawn back into the air, soon to fall again. This is the water cycle, a "wheel" of water which turns constantly like the turning of the earth itself. But in general we take water for granted. We think of it only in times of flood ar drought, or when the water available is not fit for use.

IT WOULD seem that we should never have to worry about a water shortage since the average rainfall in the Province of Quebec is 38 inches. But, our demands on water are very specific. First we must have a certain quantity of water at a certain place and time. There is plenty of water in the province as a whole, but none in some places. Secondly we must have water for many of our uses, for all water is not exactly alike. None of it in nature is absolutely pure. It contains dissolved gases, minerals and other substances. It may also contain floating or suspended particles. Some of these dissolved and floating substances are very helpful. For example, fish and other water life, cannot live without the oxygen which is dissolved in water. Some "foreign" substances are helpful in some ways and harmful in others. Some actually destroy our water supply by making it unfit for our use.

Strange to say, we ourselves are to blame for most of these harmful substances in water. And the larger and more complex our civilization becomes, the more we pollute our waterway. Cities and industries, mainstays of our modern world, contribute most of this harmful pollution.

Pollution of Water

What is river pollution? It is not easy to give a precise definition of pollution or the word *polluting*. The Oxford English Dictionary defines the word pollution as follows: "The act of polluting or condition of being polluted: uncleanness or impurity caused by contaminations".

To pollute is defined as follows: "To make physically impure, foul or filthy; to dirty, stain, taint or befoul".

Generally, we say that water is polluted when it contains substances that make it unclean or unfit for our use. There are two main forms of pollution in our waterways. The first is silt, the soil that makes our rivers brown and muddy and fills up the reservoir behind our dams. This silt would be a priceless asset, if it were allowed to stay on the land, since most of it is the rich layer of topsoil which grows the best crops and woodlands. But nature's balance has been upset by chopping down too many trees and clearing too many fields. The plants no longer hold the soil in its place, and when a hard rain falls, the water carries the soil with it into the nearest stream. Both the land and the water are harmed, but silt is chiefly a problem for farmers, foresters and soil conservationists. It is basically a land problem.

The second form of pollution consists of our unwanted wastes. These wastes are of two general types: domestic sewage and industrial wastes.

Domestic sewage includes everything that goes down the drain of a city and into its sewer system. This sewage is a cloudy and very dilute aqueous solution containing inorganic and organic matter partly in true solution, partly in colloidal solution and partly in true suspension. Soapy wastes from houses, urine and fæces are present, and there may also be paper, garbage, rags, oil, etc., floating on the surface. The water content of sewage may be as much as 99.9% or more, so that the total dry solid matter (organic and inorganic) is only 0.1% or less. Southgate[1] states that settled domestic sewage contains 250 to 400 p.p.m. of organic carbon and about 80 to 120 p.p.m. of total nitrogen, thus giving a C:N ratio of about three.

Bacteria are also present since sewage, with its varied content of easily decomposable organic matter, is an excellent medium for their development. Most sewage bacteria are relatively harmless, and belong to the class of "saprophytic" bacteria, i.e., bacteria which only feed upon dead organic matter. A few bacteria are very dangerous, since they belong to the class of "pathogenic" bacteria i.e., bacteria which cause disease in man and animals. They are therefore very important from a public health standpoint. Among the more important of the pathogenic bacteria, liable to cause infection, are the following:

1. *Salmonella typhi* causing typhoid fever;
2. *Salmonella paratyphi* causing paratyphoid fever;
3. *Shigella dysenteria* causing bacillary dysentery;
4. Bacteria of the salmonella group, causing gastroenteritis.

Fortunately, pathogenic bacteria have only a short life in water and are less resistant to adverse influences and more easily destroyed than either the normal intestinal or ordinary water bacteria. Hence it is inferred that of organisms of the B. coli group, which can easily be detected and counted, cannot be found, then the pathogens must also be absent. The predominant bacteria, in sewage and river waters, belong to the coliform group, and hence these organisms, though harmless in themselves, are used as test organisms to determine whether a water is safe bacteriologically. A list of the commoner pathogenic organisms found in sewage and polluted streams is given in Table 1.

Next in importance to sewage as a cause of stream pollution, and indeed rivalling sewage in certain districts, is the discharge of industrial waste waters. These wastes include the acids, chemicals, oils, greases, animal and vegetable matter, discharged by the various industries, and they are as varied as the character of the industrial processes from which they originate.

Those which are of sanitary significance in that they place an oxygen demand on disposal plants or on streams from a biological standpoint, are highly concentrated as to solids and oxygen demand since their total solids, suspended solids, and B.O.D. are usually very high. The cost of treatment is usually high, and to offset this at least partially, the reclamation of certain marketable ingredients in the waste is frequently attempted. Special treatments have been devised for reclaiming some of these by-products, with varying financial success; but for some wastes no practical recovery has as yet been worked out. Each industrial waste is a special problem, and general instructions on treatment are of little value. Its particular characteristics must be determined by tests and appropriate methods for handling the waste devised. In general, these wastes are considerably more concentrated than domestic sewage.

Self-purification of Rivers

Sewage and industrial wastes discharged continuously in a river may meet various fates. The river will tend to overcome the pollution load to purify itself, and to recover naturally, in the course of time. Organic matter under suitable conditions is utilized as food by bacteria, and either oxidized or reduced to products such as carbon dioxide, water, methane and others, leaving a relatively stable residue. Dissolved gases and volatile materials such as hydrogen sulphide may escape to the atmosphere. Certain materials may be oxidized chemically within a few minutes after contacting dissolved oxygen in the receiving water.

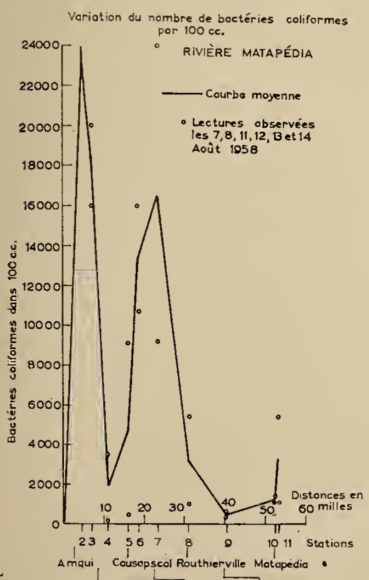
Self-purification of rivers is then one of the most remarkable of nature's workings, leading to the eventual elimination of the organic pollution, and is dependent to a large extent on biochemical reactions brought about by the activities of micro-organisms. Given sufficient dissolved oxygen these utilize the organic matter as food and break down complex compounds to simpler and comparatively harmless end-products. However, massive pollution by organic matter causes the exhaustion of dissolved oxygen. The remaining organic matter is then broken down by a different set of bacteria, the anærobic bacteria, which can utilize combined oxygen in the form of nitrates, sulphates, phosphates, organic compounds, etc. Septic conditions then occur, resulting in the breakdown of organic matter to a different set of end-products, some of which have objectionable odours and may be the cause of complaints. This condition must not be allowed to prevail.

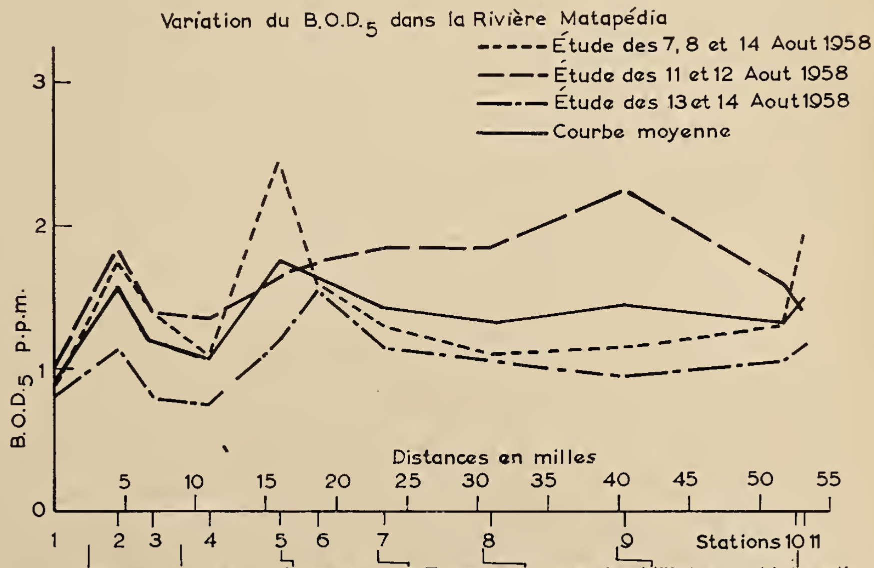
River waters must not be taxed too heavily. It is true that they must continue to receive domestic sewage and industrial wastes. This is generally recognized as an essential and legitimate water use; but there is a limit to the pollution load that a river can handle. Self-purification is a complicated process and each river has its own specific capacity for purifying itself which can only be properly evaluated after an extensive chemical, physical, hydrological and biological survey. The main factors influencing self-purification are:

Dissolved oxygen — Self-purification depends upon the presence of a sufficient quantity of dissolved oxygen. So long as oxygen is not used up too rapidly during the oxidation of organic matter by the activities of bacteria, some improvement in the condition of the stream may be expected. The deoxygenation of river water by the discharge of organic wastes may be a relatively slow process. Studies of the rate of biochemical reaction lead researchers to the conclusion that generally "the rate of biochemical oxidation of organic matter is proportional to the remaining concentration of unoxidized substance, measured in terms of oxidizability".[3]

Kind of organic matter—The rate of self-purification will depend to some extent not only on the amount of organic matter discharged, but also on its character or nature. Oxidation of the more easily decomposed organic matter as domestic sewage begins as soon as it is discharged to the stream, but some substances are more slowly broken down and a few materials such as cellulose are very resistant to oxidation, and may take many months to decompose.

Biological forces—Among the biological agencies playing a vital role in





the self-purification of streams are the bacteria, the algæ, the protozoa, the rotifers, the crustacea and the worms.

Toxic substances—Since self-purification is largely dependent upon the activities of bacteria and other micro-organisms, it is evident that the presence of any toxic substance will tend to reduce the rate of self-purification of a river, by killing the organisms or arresting their development. The extent to which the natural self-purification processes are inhibited will depend upon the nature, degree of toxicity and concentration of the chemical poison.

Physical characteristics of stream—The capacity of a stream to assimilate waste is largely dependent on its physical characteristics. Such physical characteristics as the velocity of the stream current, the slope, the depth and cross-section of the stream, the channel roughness and the character of the stream bed, are all important factors which have a marked effect on the rate of re-aeration, and therefore on the rate of self-purification. Thus, a shallow fast-flowing stream will purify itself in a much shorter time than a deep and sluggish stream.

Dilution—The ratio of the volume of polluting liquid to the volume of the stream water is of great significance, and when organic wastes are discharged to a stream, dilution plays a fairly obvious though important part in diminishing the objectionable character of the pollution. Diluting water may also prove an important means of supplying extra dissolved oxygen, though on the other hand grossly polluted tributaries may turn out to be a liability in this respect.

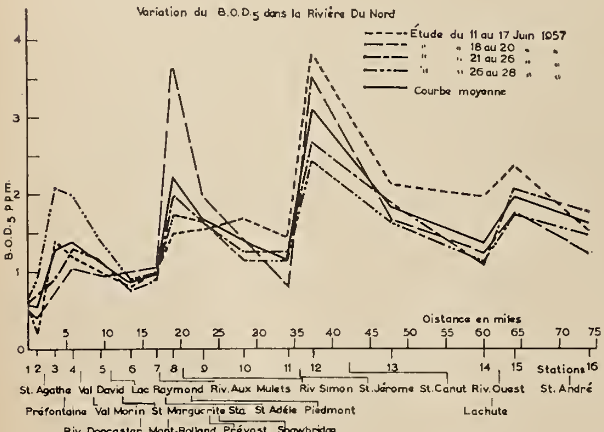
Weather conditions—Sunlight can play an important part in the self-purification of streams by promoting photosynthesis. Wind action may be of value in promoting wave action, thus increasing the rate of absorption of atmospheric oxygen and producing good mixing.

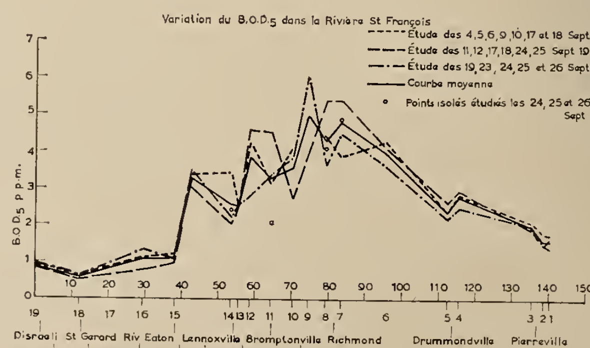
Sedimentation and sludge deposits—Sludge deposits on the bed of a stream are formed as a result of sedimentation and also by the flocculation of colloidal matter. These deposits, owing to their high oxygen demand, can affect self-purification adversely by depleting the river water of dis-

Table 1.[2]

Pathogens in Sewage and Polluted Streams

Organisms	Disease	Remarks
Virus	Poliomyelitis	Exact mode of transmission not yet known. Found in effluents from biological sewage purification plants.
Vibriocholera	Cholera	Transmitted by sewage and polluted waters.
Salmonella typhi	Typhoid Fever	Common in sewage and effluents in time of epidemics.
Salmonella	Food poisoning	
Shigella	Bacillary dysentery	Polluted waters main source of infection.
B. anthracis	Anthrax	Found in sewage. Spores resistant to treatment.
Brucella	Brucellosis—Malta fever in man. Contagious abortion in sheep, goats, cattle.	Normally transmitted by infected milk or by contact. Sewage also suspected.
Mycobacterium tuberculosis	Tuberculosis	Isolated from sewage and polluted streams. Possible mode of transmission. Care with sewage and sludge from sanatoria.
Leptospira icterohaemorrhagiae	Leptospirosis (Weil's disease)	Carried by sewer rats.
Entamoeba histolytica	Dysentery	Spread by contaminated waters and sludge used as fertilizers. Common in warmer countries.
Schistosoma	Bilharzia	Probably killed by efficient sewage purification.
Taenia	Tape worms	Eggs very resistant, present in sewage sludge and sewage effluents. Danger to cattle on sewage—irrigated land or land manured with sludge.
Ascaris Enterobuis	Nematode worms	Danger to man from sewage effluents and dried sludge used as fertilizer.





solved oxygen, and undergoing anærobic digestion. Furthermore, septic action often results in gas evolution, causing sludge to rise to the surface.

Temperature—Temperature plays a vital part in chemical and biochemical reactions, and is an important factor influencing self-purification since, according to the van't Hoff rule, the speed of a chemical or biochemical reaction is doubled by a rise in temperature of 10°C. As far as biochemical and biological processes are concerned, however, the validity of this rule is often limited to a comparatively small range of temperature in the neighbourhood of 20°C. It must also be pointed out that since warm water contains considerably less dissolved oxygen than cold water, a heavy pollution load is much more likely to deoxygenate a stream and promote septic conditions in summer than in winter.

It follows then that too much confidence should not be placed in the self-purifying capacity of a stream. In the Province of Quebec, where the rivers are relatively large, disposal of sewage by dilution is common. But the explosive population growth with growing needs and higher standards now taxes heavily the essentially fixed water resources. Furthermore, highly competitive pressures are brought to bear to commit ever more water to the various competing uses. At the same time, in many areas far too much water is made literally useless by uncontrolled pollution, so that today water pollution control very definitely is a major instrument in water resource conservation.

Pollution Control

To control the discharge of untreated sewage or industrial wastes into a stream, the Minister of Health has certain powers given to him by the "Quebec Public Health Act". These powers may be summarized as follows:

Article 57: Requires that, plans and specifications of public or private drainage works or the installation of any plant for the treatment of sewage, must be submitted to the Minister of Health for his approval. It allows the Minister to require the type of treatment needed, in view of local conditions, for any intended sewage works.

Article 59: States that no municipal by-law, relating to the construction of drainage or sewage treatment works, shall be submitted to the ratepayers, unless their plans and specifications have been previously approved by the Minister of Health.

Article 61: States that the Minister may apply to the "Public Service Board", which after investigation and after consulting the Minister, may order the construction of sewage treatment works for purposes of public health and well-being.

Article 65: States that whenever the Minister finds, after investigation, that the source of water supply of any municipality in this Province, has been rendered impure by reason of the discharge of sewage or other waste matter, or whenever he finds, after investigation, that any stream, lake or pond has been rendered so impure as to give off foul or noxious odours, injurious to the health or comfort of those living in the vicinity, it shall be the duty of the Minister to communicate the result of his investigation to any municipality, corporation or person responsible for such pollution. After having heard the interested parties, the Minister may call upon such municipality, corporation or person to take the necessary steps to do away with such causes of pollution.

Article 67: States that whenever the Minister finds, after investigation, that a sewage treatment work does not produce good results, and that the public health is in danger or that a nuisance exists on account of faulty construction or operation, it shall be his duty to communicate the results of his investigation to the municipality, corporation or person having charge of or owning such plants. Having heard the interested parties, the Minister may order such municipality, corporation or person at fault to alter the plant in such a manner as to give the results required, to the satisfaction of the Minister.

Article 69: States that any municipal corporation ordered by the Minister to do any works or improvements, in virtue of this Act, is authorized for the purpose of obeying such order, to take the necessary amount out of its general funds not otherwise appropriated and, if necessary, to borrow

Table 2

Existing Sewage Treatment Works

Location of Plant	*Owned by*	*Type of treatment*	*Receiving stream*
Asbestos	"Canadian Johns Manville"	Complete	Small brook
Beaconsfield	Municipality	Primary	Lake St. Louis
Belleterre	Municipality	Sedimentation and chlorination	Townsite lake
Bourlamaque	Municipality	Sedimentation	Pond
Caughnawaga	Municipality	Sedimentation and chlorination	St-Lawrence River
Cote St. Luc	Municipality	Sedimentation	Rivière St-Pierre
Drummondville	Municipality	Sedimentation and chlorination	Rivière Noire
Gagnonville	Municipality	Primary	Discharge of Lake Barbel
Hemingford	Municipality	Sedimentation	Odell brook
La Petite Rivière	Municipality	Sedimentation	St-Charles river
Laprairie	Municipality	Sedimentation	St-Lawrence Sea Way
Maria	Hospital	Sedimentation and chlorination	Baie des Chaleurs
Mont-Apica	Department of National Defence	Complete	Upica river
Noranda	Municipality	Complete	Lake Osisko
Parent	Department of National Defence	Primary	Lake Grant
Pierrefonds	Municipality	Sedimentation and chlorination	Des Prairies river
Pincourt	Municipality	Sedimentation and chlorination	Lake St-Louis
Plessisville	Municipality	Primary	Blanche river
Pointe Claire	Municipality	Sedimentation and chlorination	Lake St-Louis
Princeville	Municipality	Primary	Blanche river
St-Adolphe-de-Howard	Department of National Defence	Complete	Lake St-Denis
St-Ambroise-de-la-Jeune-Lorette	Municipality	Sedimentation	St-Charles river
St-Constant	Municipality	Sedimentation and chlorination	St-Pierre River
St-David-de-Falardeau	Municipality	Sedimentation and subsurface drainage bed	Lake Clair
Ste-Foy	Municipality	Sedimentation and chlorination	Small brook
St-Hilarion	Municipality	Sedimentation and subsurface drainage bed	Small brook
St-Hubert Airport	Department of National Defence	Complete	Small brook
St-Jacques l'Achigan	Familial Institute	Primary	Small brook
St-Léonard-de-Portneuf	Municipality	Sedimentation and chlorination	Small brook
Ste-Monique-des-Saules	Municipality	Sedimentation	St-Charles river
Ste-Pudentienne	Municipality	Sedimentation and chlorination	Mawcook brook
St-Sylvestre	Municipality	Sedimentation and subsurface drainage bed	Small brook
St-Sylvestre	Department of National Defence	Complete	Small brook
Ste-Therese	Municipality	Sedimentation and chlorination	Mille-Iles river
Ste-Therese-de-Blanville	Department of National Defence	Complete	Riviere aux Chiens
Schefferville	Quebec Iron Ore	Complete	Pearce Lake
Valcartier	Department of National Defence	Complete	Nelson river

such amount by by-law without being obliged to observe the formalities regarding loans required by the laws governing such municipality.

Existing Sewage Treatment Works

In virtue of these powers granted to the Minister, certain municipalities were asked to provide sewage treatment works in order to treat partially their sewage before discharging it into a stream. The existing sewage treatment plants are shown on Table 2.

Furthermore the municipalities shown on Table 3 will provide during the coming year a certain type of sewage treatment:

Table 3.
Intended Sewage Treatment Works

Location of Plant	*Owned by*	*Type of treatment*	*Receiving stream*
Fabreville*	Municipality	Primary	Mille-Iles river
Henryville	Municipality	Sedimentation	Riviere du Sud
Henryville	Dairy Elmhurst	Complete	Gariepy brook
L'Annonciation*	Hopital des Laurentides	Primary	Riviere Rouge
Notre-Dame-de-Lorette	Municipality	Sedimentation and chlorination	Lorette river
Pierrefonds*	Municipality	Primary	Des Prairies River
Pointe du Moulin*	Municipality	Primary	St-Lawrence river
St-Donat*	Municipality	Sedimentation	Ouareau river
Ste-Dorothée*	Municipality	Primary	Des Prairies river
St-Gabriel-de-Brandon	Municipality	Primary and filtration	Discharge of Lake Maskinongé
St-Placide	Municipality	Primary	Lake Deux-Montagnes

*These plants are now under construction

In the past few years, real progress has been made in stepping up the construction of essential municipal waste treatment for the intended sewage works in the Province of Quebec. A good example of this progress is a revolutionary new method for destroying the bacteria, odour and organic materials in settled, primary raw sewage sludges. This method is called the "Atomized Suspension Technique" and was developed by the Pulp & Paper Research Institute of Canada. In this unit the sludge is atomized with pressure nozzles into an empty tower whose walls are held at a temperature varying from 1400°F at its top to 1000°F at its bottom by four banks of electric heaters controlled individually and automatically. As the water in the atomized spray flashes into superheated steam, the solid particles are completely dried by the time they have fallen half-way down the tower. At this point, air is introduced at low pressure from a compressor so that the solid particles may be combined with the oxygen in the air. The organic material is then burnt to a dry, fine dust or harmless inorganic ash. This unit takes the place of the costly, slower method of sludge digestion followed by the drying beds and then disposal of the dried solids, with its attendant handling costs and nuisance problems.

But the major difficulty was the lack of data on actual stream quality to determine the degree of treatment needed to eliminate undue pollution in a given stream.

Water Pollution Committee

On December 1st, 1955, the Lieutenant-Governor in Council was authorized to form a committee of not more than five persons to study the problem of the pollution of the waters of the public domain of the Province. This committee was asked to inquire into the nature and causes of the present pollution of waters of the public domain, try to find out the remedies therefor, and the measures required to prevent further cases of pollution, and report its findings and suggestions to the Lieutenant-Governor in Council. The members of this committee were named in August 1956.

Following a request from this committee to the Minister of Health for the necessary data on stream quality, the Sanitary Engineering Division of the Department of Health undertook to make a preliminary study on certain rivers presenting complex and difficult problems for an efficient control caused by sewage and industrial wastes. The first rivers chosen were the North river, the St-Francis river and the Matapedia river.

Field Work

For each of these rivers, a sanitary survey of the entire watershed drainage area was made in order to determine the actual and potential sources of pollution. This meant that attention was given to the location of sewage treatment plants, bathing areas, storm drains, sewer outfalls, industrial wastes outfalls, and water intakes. To collect this information, visits were made by a sanitary engineer to the secretary-treasurers of municipalities in the watershed drainage area of the river under consideration. Visits were also made to industrial establishments to determine the pollution load contributed by these industries.

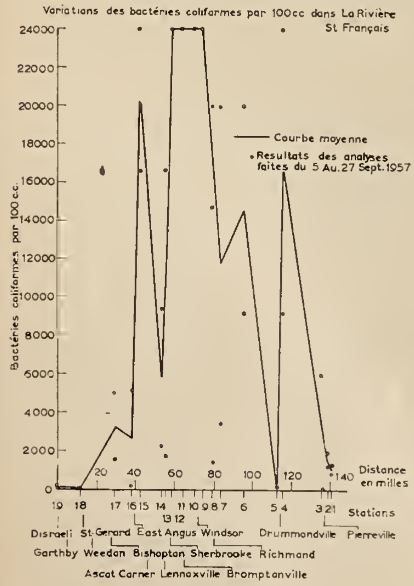
To complete this preliminary study, bacteriological, chemical and physical examinations of the river water were also made by trained personnel equipped with a mobile laboratory. That work included mainly the sampling and analysis of river water.

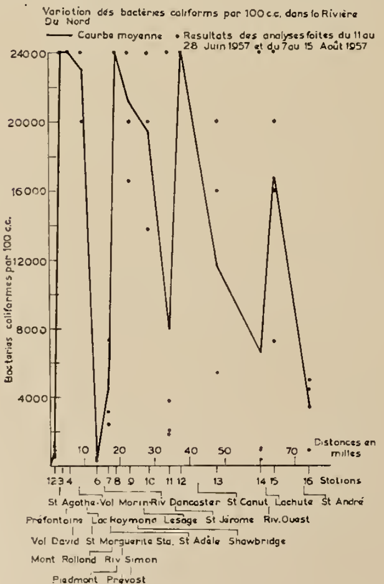
Sampling—Samples were taken upstream and downstream of main sources of pollution to determine their influence on the quality of the river water. Some samples were also taken to determine the self-purification capacity of the river. Finally, some samples were taken on the main tributaries to determine their contribution to the river pollution.

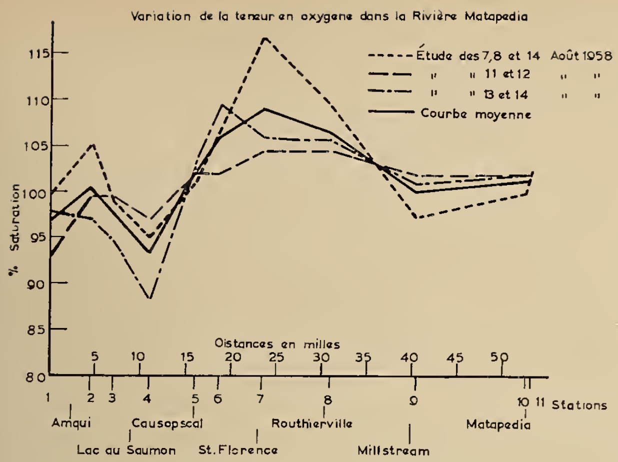
The number of sampling points was the following on each river: 16 on the North river and 3 on its tributaries; 19 on the St-Francis river and 3 on its tributaries; and 11 on the Matapedia river.

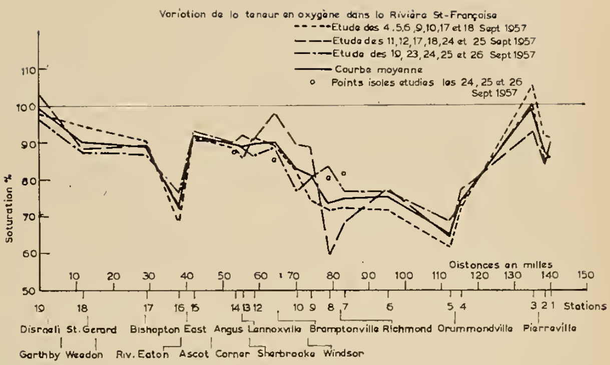
The sampling procedure was in accordance with the sampling directions given in the 10th edition of "Standard Methods for the Examination of Water, Sewage and Industrial Wastes", published jointly by the American Public Health Association, The American Water Works Association and The Federation of Sewage and Industrial Wastes Associations.

Analytical work — All analytical work was made in accordance with









the 10th edition of "Standard Methods . . ."

The field work included the determination of turbidity, pH, temperature, dissolved oxygen and five day biochemical oxygen demand (B.O.D.). Oxygen is needed for the respiration of the organisms that are responsible for the aerobic decomposition of organic matter. Therefore, a determination of the amount and rate of oxygen utilization furnishes one of the best means for estimating indirectly the amount of decomposable matter contained in a water. This determination is called the biochemical oxygen demand, or B.O.D.

The bacteriological examination was made by the Ministry of Health Laboratory in Montreal. That bacteriological examination involved the research of the coliform group of bacteria which is considered a satisfactory indicator of pollution, because these bacteria are found in large numbers in domestic sewage. The result is expressed as the most probable number of organisms per 100 millilitres (MPN per 100 ml.).

The nine graphs represent the variation in five day B.O.D., dissolved oxygen and coliform counts along the three rivers we have studied in the years 1957 and 1958.

Recommended Stream Quality

For drinking purposes — As an aid in determining the treatment of water to make it safe to drink, the United States Public Health Service has classified waters into several groups.[4] The treatment required by this classification is summarized in Table 4.

For water to be generally acceptable, however, other treatment may be required in addition to that necessary for the elimination of disease-producing organisms.

For fisheries — Ellis[5] has given the minimum dissolved oxygen content of water for maintaining fish in healthy condition as 5 p.p.m. at 20°C, or about 57% of saturation, and other authors give figures of the same order of magnitude. Game fish (e.g. salmon and trout) require more dissolved oxygen than do coarse fish.

Other factors may also influence the presence or absence of fish, for example the temperature, the pH, the toxic substances, the geological nature of the strata through which the river flows, the physical character of the stream and of the stream bed, the strength of the current, the relative abundance and nature of the plant life and the fish food present.

For recreational use — Water for recreational use (boating and bathing) should not only be free from colour, odour, or anything visible of an objectionable nature (such as sludge banks, suspended matter, floating material and oil) but also should not contain anything injurious to public health.

In the U.S.A. a number of States have put forward standards for outdoor bathing waters based upon the B. coli count. For example, the Connecticut State Department of Health[6] has proposed a classification of these waters which is given in the following table:

Class	Condition	Average B. coli count per 100 ml.
A	Good	0—50
B	Doubtful	51—500
C	Poor	501—1000
D	Very poor	Over 1,000

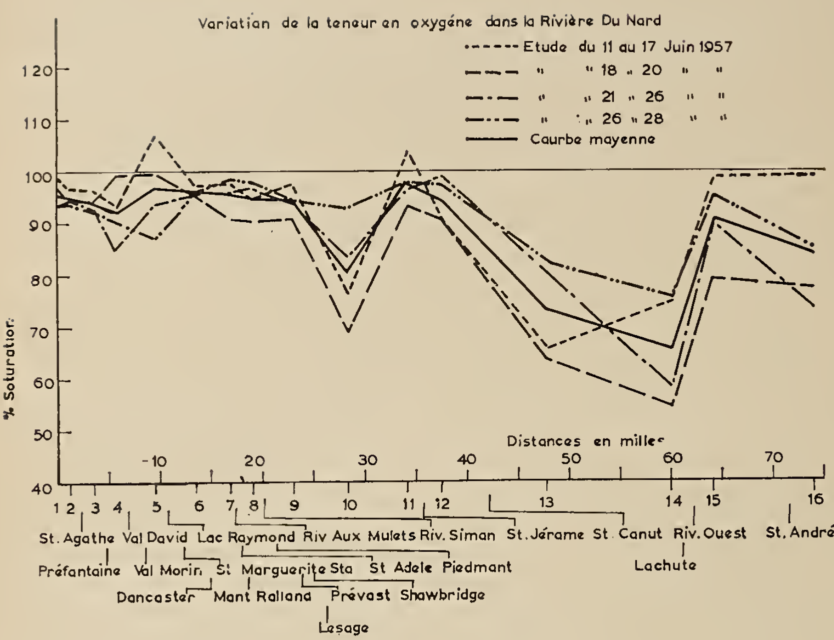
The use of this classification is recommended by the Joint Committee on Bathing Places of the Conference of State Sanitary Engineers and the American Public Health Association.[6]

However, experience allows us to state that bathing is safe in natural waters with a coliform count inferior to 2400 per 100 ml.

For outfalls — A rule of thumb

Table 4

Group No.	Maximum Permissible Average MPN Coliform Bacteria per Month	Treatment Required
1	Not more than 10% of all 10-ml. portions positive; approximately less than 2.2 coliform bacteria per 100 ml.	No treatment required of underground water, but a minimum of chlorination required of surface water.
2	Not more than 50 per 100 ml.	Simple chlorination or equivalent.
3	Not more than 5000 per 100 ml. and this MPN exceeded in not more than 20% of samples.	Rapid sand filtration (including coagulation) or its equivalent plus continuous chlorination.
4	MPN greater than 5000 per 100 ml. in more than 20% of samples and not exceeding 20,000 per 100 ml. in more than 5% of the samples.	Auxiliary treatment such as 30-90 days storage, presettling, prechlorination, or equivalent plus complete filtration and chlorination.
5	MPN greater than 20,000 per 100 ml.	Prolonged storage or equivalent to bring within Groups 1–4.



giving a rough estimate of the required dilution is that untreated, combined sewage may be discharged safely into streams that carry 10 cfs of water per 1,000 persons contributing sewage. However, the required dilution may vary according to the swiftness of streams. For domestic sewage, treated sewage, and industrial wastes, that figure can be apportioned to the relative amount of putrescible matter present. Where the emphasis is on water supply, recreational use of water, and preservation of fish and other useful aquatic life, rather than on the avoidance of nuisance, dilution requirements become very much larger. If available dilution is inadequate, the sewage must be treated before disposal by dilution. These dilutions are permissable on account of the self-purification capacity of streams as already explained in the present article.

However, the de-oxygenation of river water by the discharge of organic wastes may be a relatively slow process. Hence it happens that the point of maximum de-oxygenation usually occurs a considerable distance (often many miles) below the point of discharge, depending on the rate of self-purification. Determinations of B.O.D. and dissolved oxygen at various points in the river are necessary to assess the extent to which self-purification has proceeded.

The Royal Commission on Sewage Disposal[7] considered that the dissolved oxygen content of a river should not fall below about 60% of saturation in the summer if nuisance was to be avoided, but it is generally considered nowadays that this gives a fairly wide margin of safety.

That Commission[8] took the view that a river giving a five day B.O.D. (18.3°C) of 4 p.p.m. would be on the verge of causing nuisance. That figure forms the basis of the following classifications taken from the Royal Commission Reports.

Observed condition of stream	5 day B.O.D. (18.3°C) p.p.m.
Very clean	1
Clean	2
Fairly clean	3
Doubtful	5
Bad	10

Considerations Arising from these Studies

From our results and recommended standards, we could suggest some limitations applicable to the many uses that can be made of the three rivers we have studied. However, on the basis of results from that preliminary survey, it is not desirable to draw at the present time too detailed and far-reaching conclusions.

In spite of the high self-purification capacity we have observed especially in the North and Matapedia rivers, it can generally be said that treatment of industrial and domestic sewage, especially where highly concentrated, will be necessary to allow the use of these rivers for drinking, industrial, fisheries and recreational purposes.

Other rivers under study by the Sanitary Engineering Division are the St. Charles river, the Yamaska river and Lake St. Louis. All studies made up to now were only preliminary. To classify these rivers according to best use in the interest of the public and to determine the sewage treatment needs, a more complete study will have to be made on each of them.

Conclusion

Real progress has been made in the Province of Quebec regarding water pollution control. Under the present legislation, sewage treatment works were built to treat the sewage of certain municipalities, but the Legislative Assembly may have to give larger powers to permit a sewage treatment works construction program tending towards a better quality of receiving waters.

Interest in determining the capacity of natural waters to assimilate wastes will increase in the future as greater emphasis is placed on water pollution abatement. But at present people in the Province of Quebec too often say that paying for sewage treatment means paying for goods they never receive since other towns seem to get all the benefit from their expenditures. They must decide definitely and finally if they will take the road of the conserver and wise user. The choice is theirs. They must choose wisely and soon, for time and our rivers will not wait.

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A STUDY OF THE USE, CONSERVATION AND POLLUTION OF WATER RESOURCES

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In July, 1959 the author presented a Brief to Honourable E. Davie Fulton, Minister of Justice and Attorney General of Canada, entitled: "Some Aspects of Water Pollution and Some Recommendations for Action on Water Pollution Control by the Government of the Dominion of Canada." This paper is intended to support, and if possible, advance the Brief; firstly, by offering a more detailed review of the concepts involved if action is considered by the Dominion Government and secondly, by encouraging other Canadians to publish their views on this subject. The great amount of work that has been done in the United States in recent years should be very useful to Canada. In this country there is awareness of the problems of water resources and pollution, but coordination and leadership are required. In order to realize the need for anti-pollution work, it is first necessary to understand fully the general principles of conservation and the state of our water resources; therefore this paper deals with these matters at considerable length. The paper concludes with a strong plea for positive action by the Dominion Government and presents a suggested list of research and development projects that could serve as a nucleus for a much needed Dominion program.

THE American anti-pollution work should help Canadians a great deal, especially when we consider the similarity in cultural pursuits, kinds of industry, urban growth patterns, highway building, standard of living, recreation, many points of similarity in topography, climate, geology and hydrography.

In the United States Dr. M. D. Hollis[1] has taken a strong stand for several years. He says that the use and misuse of water, has become a major national issue. Dr. Hollis warns that the current growth of population is taxing water resources that are essentially fixed and that a continuous avalanche of technological changes is outmoding the traditional parameters.

It is claimed that the U.S. population (now 178 million) will be 250 million by 1980; therefore the United States Public Health Service (U.S.P.-H.S.) believes that the continuing avalanche of technological change will be at an ever-increasing tempo, with very significant effects on resources.[2]

In the United States so far the philosophy of treatment has been to do the job in the most economical way—treat the waste a minimum amount and let Nature do the rest, sometimes without proper regard for the time and forces available to her for the extent and increasing complexity of the work required. The U.S.P.H.S. are currently estimating that much of the American yearly water supply must soon be re-used at least six times to meet the demands.

Watson[3] described the wave of State legislation that has resulted from their national pollution problem. He emphasized the importance of inter-State pacts to handle the problem on a river basin basis, and the importance of the over-riding Federal authority. Geuther[4] states that from 1953 to 1956 there were 269 bills (State and Federal combined) dealing with water pollution, with much of this legal activity revolving around the question of proper doctrine.

In summary, as stated by Grayson,[5] the United States have become a nation with "push-button" luxuries and "push-button" shortages. There are shortages of schools, highways, hospitals, housing, water supply facilities and sewage facilities. Action is predicated upon the *understanding* of the people. It seems fully evident that the American resources have some serious limitations, which require action, now, and tremendous expenditures.

Perspective of Canadian Situation 1960

The International Joint Commission for Canada and the United States began in 1909 and has always been concerned with works that might affect the levels of boundary waters and other problems along the borders on a request basis from both Governments.

The work of the Ontario Water Resources Commission is outstanding. This agency is unique in the history of water resource development and anti-pollution because of its very broad and important powers. The O.W.R.C. can force action, finance, construct, acquire, operate and maintain both water and sewage plants. It can control and regulate the collection, production, treatment, storage, transmission, distribution and use of water. It can conduct research programs and prepare statistics for its purposes.

The Greater Winnipeg Sanitary District has instituted a surcharge By-Law that has enabled industry to see where it stands. As a result, it is getting the action required. In New Brunswick, an Act has been passed, recently, which sets up a Commission along lines quite similar to the O.W.R.C. In Quebec, the Provincial Government is making a very careful study of the problem. It is considering a report from the Quebec Water Pollution Committee which seems to be strongly in favour of setting up a Quebec Commission similar to the O.W.R.C. Nearly all of the residential communities adjacent to the waters around the Montreal area are looking to swimming pool construction as a part answer, rather than construct the sewage plants that *must come eventually*. Some communities with both septic tanks and wells are beginning to experience chloride contents in their wells that indicate the need for a careful survey.

At Ottawa, Hon. J. W. Monteith (Minister of National Health and Welfare) on February 2, 1960 announced that his department will expand its research facilities to include a new environmental health centre. In addition, a conference is being planned by the Department of Northern Affairs and National Resources to be held in 1960 under the heading "Resources for Tomorrow". At the present time there is a private bill before the Dominion Government, known as Bill C-34 — "An Act to Amend the Criminal Code". This proposes very high penalties to industry for polluting water.

In Canada today, there are several strong Government organizations actively concerned with this problem. There are varying degrees of awareness of the general pollution picture at all levels of Government. Some Boards of Trade, some technical groups and some service organizations are pressing for action. This is a general picture for the Dominion, but to date many of these efforts, although well-meaning, are not founded on a scientific analysis of the problem or even on sufficient background information, and there is a great need for coordination and leadership.

We need guidance to maintain the quality and quantity of our most important natural resource. Already thousands of square miles have been fished out, shot out, cut over, depleted and polluted, so that both pleasure-seeker and businessman alike are being cheated of their rights.

Some Conservation Concepts

Some people are still shocked by the idea that Canada must conserve her resources; they are still thinking of the wide open spaces of Canada—the granary of the world, etc. These people think that man's chief idea is to *conquer* nature, without realizing that man will remain at the top of creation *only by working with* Nature.

Conservation is the informed, conscientious management of resources; it is development as well as protection; it is use as well as saving. A conservationist is not a hoarder but a person who makes judicious choices; he has three general principles:

He matches the resource and the use so that there is a minimum of waste in either quantity or quality;

He uses recurring resources wherever possible instead of fixed resources;

He protects his sources of supply.

Water is a basic resource which has suffered because of poor understanding and our casual attitude. It has been wasted by unnecessary run-off and excessive use in industry, home and irrigation. Conservation or wise use of resources is primarily a matter of education — educating ourselves to a very important need through the continuous critical correction of past errors. We must come to a full realization of the concept that our natural resources belong to a vast family, of whom many are dead, few are living and countless millions are still unborn.

In our society there will always be exploitation, hence we must have public controls to bring exploitation in line with social objectives. It is hoped that public control would regulate the distribution of water resources (for example, ground water) and thus maximize the return to society, both present and future. In other words, a comprehensive, basic legislative authority should be the cornerstone upon which the maximum conservation and development of water resources will be accomplished for the greatest benefit of all.

Control and supervision must be at least province wide, because all conservation activities must be coordinated. Uniformity of standards can be a very troublesome concept in conservation work, especially in regard to streams, but there must at least be a uniform approach over as wide an area as possible to protect the public interest. Many of the leaders in the anti-pollution and conservation work of the U.S. are convinced that a centralized national agency with strong supporting legislation is absolutely vital to an effective program.[6] We, as a collection of thousands of locally autonomous communities, urgently require a strong over-riding force to choose the desired end use of water which will achieve the greatest public benefit.

Conservation and management of resources require a high degree of skill and many trained people. For example, reservoir management requires a great deal of skill, particularly when the reservoir is used for several purposes such as hydroelectric power and irrigation. It is necessary in this case for the manager to know such facts as the evaporation from the surface, the time and amount of each need, and the expected run-off. In this matter of reservoir evaporation, there may be good possibilities in the use of hexadecanol or octadecanol as a monomolecular surface film to reduce evaporation from a reservoir surface. According to Taylor[7] these chemicals have great promise and have no ill effects on fish or fowl.

Laws are essential in conservation and anti-pollution work and yet neither statutory nor common laws will necessarily prevent water use problems. Before administrative machinery can work properly we must understand the hydrology of any particular water resource, and the public must be informed of the broad social needs of the country. Leopold[8] stresses the concept of water management rather than specific administrative doctrines. He advocates the development and management of resources with an adequate system of continuous appraisal.

Scientific watershed management is becoming increasingly important. Watersheds are affected by forest fires, erosion from overgrazing, over-cutting of timber, etc. According to Taylor[7] only about 20% of rainfall is used productively; some evaporates and the rest is wasted. In our highly developed society, our standards are greatly influenced by our treatment of watersheds which, in turn, control sources of supply, floods, water tables, erosion, land fertility and to a great degree, pollution. Some authorities strongly advocate restriction of access to all watershed head water areas.

Recently certain conservation concepts have changed our thinking. For example, Dibble[9] has discovered that some plants transpire excessively and that it is possible to make far greater use of land in some dry areas by using certain water-thrifty plants.

Upson[10] points out that we should be concerned about discharging sewage to the sea because this practice places fresh water beyond the possibility of recycling in addition to polluting beaches, fisheries, etc.

The reclamation and re-use of water must become a firmly entrenched principle in our society. We simply must realize that some of our modern gadgets are extremely wasteful of both water and sewage plant capacity. For example, our modern living has the joys and the *problems* of automatic dishwashers, automatic laundry machines, and extensively used air conditioning equipment. Garbage grinders increase the water consumption and they also affect sewage treatment.

On the positive side of this story, there is the possibility that the future will see extensive conversion of sea water for domestic purposes in the dryer parts of the world.

Finally, a very important aspect of conservation is popular understanding. According to Grayson[5] public education regarding sewage, water pollution and water resources is essential and money is not the problem; the people do not understand the urgency of these problems.

Our Water Resources

Even though we occasionally suffer deluges and though we know that our earth's water resources are permanent and indestructible, we must also realize that the amount available and its quality at a given place and time are changing. Ignoring the possibility of mining water, the total annual supply is equal to the annual precipitation; this is an almost constant amount. These facts add up to serious shortages in some localities.

Some of these shortages are local and are due to poor distribution or deterioration of quality by industry, municipality or agriculture. Also we can partly correct our water difficulties by making full use of the fact that water is one of our more renewable natural resources; it can be re-used several times in the course of its hydrologic cycle.

Many of our water problems are the direct outcome of efforts to adapt our physical environment to our economic and social needs without reckoning sufficiently on Nature's ways. The most damaging impact of civilized man on his environment is the shattering of the water cycle. In Canada, before the advent of the white man, there was a mutual society of balance among waters, soils, grasses, forests and animal life. Each member of this society contributed its powers of control and protection and was, in turn, controlled and protected. It is useless to spend millions on river control and valley development unless this work is accompanied, for example, by reforestation and good, overall watershed program.

It is becoming more and more evident that our water problems are due to a combination of regional shortages, ineffectual control of pollution and unsolved technical problems. There is a fourth reason that will be dealt with further, namely, the uneconomic pricing of water. Incidentally, we frequently mean insufficient capital investment when we use the words "ineffectual control of pollution."

Water Supply Problems

We have referred to uneconomic pricing as a major cause of our water problems. Undoubtedly there is an obvious need to promote certain social and sanitary uses of water through low pricing, but there also should be much closer adherence to orthodox principles of pricing. There should be extra costs paid by those who deplete or degrade our water resources. Water rate determination is complicated by the necessity of providing fire protection, by politics, and by the very essentiality of water to our existence. However, we certainly must weigh availability against the fact that the installation of meters has been known to reduce water consumption by 50%.

According to Hines,[11] water prices are a hybrid of economic and social forces. The unusual versatility of water as a low cost economic good permits it to satisfy a great variety of private and collective wants but also leads to special problems in pricing and allocating. Some experts have sought to establish water prices according to the value of the end product. This does not seem sound. We have plenty of evidence that water is not priced properly, which of course all ties in with the water resource problem. For example, there are only a few private water companies; water rates do not reflect construction costs and policies differ widely.

The price of water is closely related to our sewage treatment and water pollution problems. The quality of raw water, which greatly influences the price of finished water, is itself largely dependent on how much treatment is given to sewage by the upstream community, when the source of supply is a flowing stream. The net cost of water treatment for a community is also dependent on the condition of its own sewage effluent (being much less if no treatment is given).

Although we shall deal more specifically with water rights and water laws later, it is necessary to point out now that certain guiding legal principles are likely to be forced on us to correct some water supply problems. Water supply facilities are becoming more costly and more complex, hence investment requires more security. This will lead to such measures as:

refusal to grant exclusive control over water;

complete public ownership of all water supply;

ground and surface waters treated as one.

Undoubtedly our future water laws must permit some flexibility but this will certainly require a good system of checks and balances.

Radioactivity is adding to the general supply problem, and there are many unknown factors about pollution with radionuclides. It is known that many radionuclides are isotopes of elements which have biological importance and enter into many biochemical processes. Some radionuclides are accumulated by aquatic life to a very high degree. Some radioisotopes accumulate in bone while others accumulate in soft tissue. Apparently, fish may accumulate radioactive cæsium in their muscles to levels 20 to 50 times the radioactive level of the water, thus making the fish very dangerous for human consumption; fresh water fish concentrate radioisotopes to a much greater degree than do salt water fish, particularly when the fresh waters have a low calcium content. Bottom layers seem to have great absorptive capacity for radioactive materials. The biota in the mud degradate the oranic matter, transferring chemical components from one organism to another. Then soluble salts, together with the organisms, are gradually lost downstream along with their radioactivity. It is argued by some[12] that great care is necessary in monitoring and releasing radioactive wastes to surface waters.

Bernard Baruch once said that water eventually will be more valuable than oil. Perhaps we shall all realize this before long.

Ground Water Problems

Thomas[13] states that when ground water storage is used properly in conjunction with good surface storage, the annual water yield may be increased to about 85% of the average natural supply. The importance of cooperation between industry and municipality is paramount for protection of ground water supplies. Most of us require education in this matter and research must provide much needed data before we can deal adequately with the problems of locating, recharging, conserving and contaminating our ground waters, in addition to the complex legal problems.

The problem of locating ground water is linked closely with evaluation; Kleiser[14] and Miller[15] agree on the general approach to this problem and have outlined some of the methods involved. The basic starting point is a careful study of the general geology of the area. Next, there must be an analysis of all the available well records. Experienced engineers point out that authorities should insist on drillers keeping better records. Adequate information about wells could be invaluable to a water resource program. The required data are:

full results of resistivity surveys where done;

depth and thickness of water-bearing formation;

chemical quality and quantity of water produced originally and periodically;

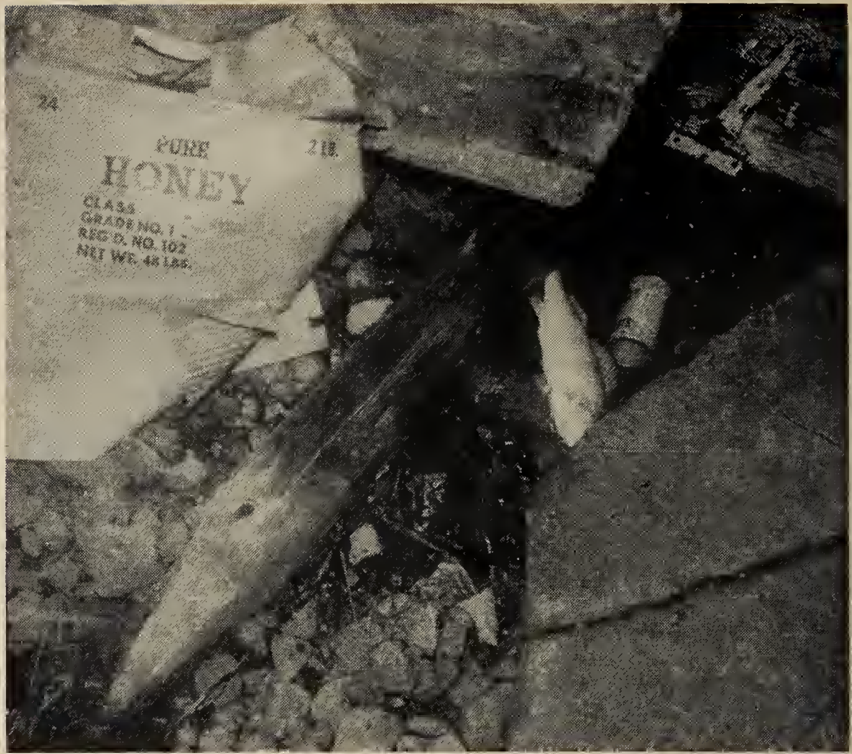
results of all test holes, resistance measurements, seismic surveys, performance tests, etc. for each area in question.

The well drillers might be incorporated into a national fact-finding program.

Various methods have been proposed for recharging ground water storages but all have difficulties. The methods proposed are surface ponding, injection and induced infiltration. Surface ponding is hampered by a gradual loss of permeability. Well injection suffers from chemical precipitation, air-bubble locking, sediment or organic materials. Infiltration, induced by manipulation of ground water levels and by controlling surface-storage reservoirs, is still in its infancy.

A great deal has been written about the California ground water problems; much of this does not apply to our Canadian picture. However, we should mark well the results of California's past disregard for its once extensive ground water resources. Richter and Chun[16] point out that Californian water levels are declining enough to permit alarming sea water intrusion in many areas. They emphasize that much of the trouble is due to human activities, such as sealing natural recharge areas with airports and discharging unnecessary amounts of fresh water into the ocean via sewage disposal systems.

Richter and Chun point out that recharge rates are affected by the natural ground slope, properties of the surface soil (permeability, depth, organic content, etc.) procedures used in the construction, operation and maintenance of a recharging project, the quality of the water involved, and by the geologic and subsurface hydrologic conditions.



Pure honey cartons, rotting fish and old tin cans hardly breed pure water.

Ground water may be mined, and because of this possibility society can, if desired, make a choice between present and future use of a ground water supply. This choice should be made by people who are concerned with the national problem and completely removed from political influence. As an example of the problem it is noted that the underground water level has fallen so much in the Baltimore area that wells must now be drilled 140 ft. deeper than in 1916.

If conservation requirements are to be met, a great deal of water that has been used and perhaps has passed through a sewage treatment plant, *must* be used for recharging ground water resources. Unfortunately there are considerable hazards in this course of action but the hazards must be overcome. These dangers stem from the possible presence of pathogenic organisms (bacteria, viruses, intestinal worms, protozoa) and toxic substances. In addition, such reclaimed water may eventually permit excessive build-up of dissolved salts, and the soil formations may become clogged through the development of bacterial slimes.

Contamination of ground water may also occur on account of poor well-drilling practices. Schmid[17] has suggested that all wells should be supervised and regulated to avoid polluting ground water. He advocates special precautions to keep drillers from violating codes, working alone without sufficient experience, ignoring the Board of Health and using inferior methods.

The legal problems associated with ground water are complex. Thomas[13] has pointed out that the laws governing ground water storage should allow for storage in one area to be used in a distant area if necessary. Gates[18] asks a few pertinent questions on the subject of piping ground water from one area to another, such as: Will the adjacent owner's land be made arid by the lowered water table? If another locality uses the same ground water source how should the rights be allocated?

Before ground water legal problems can be settled there must be agreement on definitions. For example, Gisvold[19] claims that a distinction must be drawn between underground water flowing in a defined channel and underground percolating water. Gisvold would subject underground streams to the same laws as surface water but deal differently with all other underground water. This is contrary to hydrologic principles because all water comes from the same source —rain and snow. As Piper[20] says, ground and surface waters are interrelated and must be dealt with by a single legal principle.

Surface Water Problems

This subject will be dealt with later when we discuss pollution more specifically, but there are one or two special problems that have a strong influence on surface waters. These are the problems relating to reservoirs, (impoundments or storage).

Dams impound water for power production, flood control, navigation, irrigation, and storage. In addition to fulfilment of these purposes, additional benefits accrue such as recreation and removal of sediment from turbulent rivers. However, a serious disadvantage results with conventional, modern dams. Dissolved oxygen is greatly reduced and the river thereby loses the greater part of its waste-assimilating capacity for very considerable distances below these dams. This problem is particularly troublesome for the storage type of reservoirs; these are usually 100 to 125 ft. deep, with the water being retained in them with negligible flow velocity, for one year or so, and discharge intakes very low in the dam so that the outflowing water is always drawn from the hypolimnion stratum. The hypolimnion stratum is cold, dense water, too deep for light penetration, hence no photosynthesis occurs in it and the dissolved oxygen may become negligible after a few months of oxygen usage by the natural organics which settle.

Kittrell[21] offers some possible solutions to this reservoir problem that might be considered by our power development people. For example, he suggests multilevel penstock intakes, high level penstock weirs, changes in tailrace design, use of aeration chambers, pumping from hypolimnion to epilimnion. It is quite conceivable that it might be cheaper to keep these large reservoirs mixed by pumping than to bear the added cost of the sewage treatment plants, which are made necessary by the loss of the natural waste-assimilation capacity.

Another aspect of impoundments is that they are permitting the water to settle so that the top layers are liable to promote better algae growth than before building the dams. This, plus inadequate sewage treatment, is causing taste and odour problems, filter clogging, and growths in pipes and reservoirs.

Industrial Water Problems

Water problems in industry are due to the lack of both quantity and quality, which, of course, is no different from the problem faced by many municipalities that are concerned only with domestic consumption.

However, the industrial water problem merits special mention because localities that do not have plenty of suitable water or a means of obtaining it, are not likely to experience significant expansion through industrial growth. In other words, there will be a shortage of employment in those areas.

Quite apart from the problems involved in the re-use of water, many present day industries are faced with complex production problems because of impurities in their water supply or because of insufficient water of any kind. Such industries include textiles, pulp and paper, electroplating, packinghouses, beverages, dairies, all of which use water directly in their processes. In addition, many industries that use large amounts of steam would welcome water that is less costly to treat.

Eventually, it is hoped, there will be sufficient surveyed and recorded data on our water resources to permit direction of a given industry to an area which has water suitable for the processes in question.

Reclamation and Re-use of Water

Many senior American engineers are proclaiming the need to re-use water several times. Re-use will entail improvements in sewage treatment in order to maintain the quality of water and avoid harmful effects from re-using it. In addition there may be legal problems arising from the use of ground water or other supplies of inferior quality.

Bookman[22] describes the problems, possible uses and need for water reclamation in California. Bookman claims that approximately 28% of the water used in California ends up in the ocean and that this amount will increase because ocean disposal is cheap, offers a high degree of dilution, requires less pretreatment, and is essential for disposal of some saline and toxic waste. However, even though reclamation is expensive and involves problems it will be increasingly essential in the future.

Reclamation problems arise from the increasing use of synthetic detergents which either affect the sewage treatment process or cause the reclaimed water to foam. The possible build-up of toxic waste and mineral salts must be considered and corrected, if necessary. There is a distinct possibility that pathogenic viruses and bacteria could contaminate ground waters. Better monitoring techniques are necessary to protect health and industry before reclamation can be considered on a large scale. Moreover if an industry agrees to use reclaimed water, it would certainly require a good measure of uniformity in the water it receives; this might be difficult if a number of sewage plants contributed to such a scheme.

The use of reclaimed water for agriculture underlines the necessity for very good treatment since Kabler[23] has shown that wet sludge and settled solids may require 12 to 15 months' atmospheric drying to kill pathogenic bacteria. In addition, it will be necessary to guard against such chemicals as boron which is very toxic to plant life, and insecticidal or herbicidal chemicals could kill crops and sterilize the soil.

Whenever reclaimed water is used for ground-water recharge, there must also be ample distance between the points of recharge and re-use, to overcome the aesthetic objections and provide dilution.

We can conclude that wherever we face the necessity of reclaiming and re-using water, we shall certainly be obliged to provide a very high degree of secondary, oxidation type of treatment plus disinfection.

The legal side of the reclamation picture also requires some careful thought. At the present time, some problems could conceivably arise owing to the differences between statutory and common law riparian rights. For example common law riparian users are obliged to return water to the originating stream whereas statutory users do not have this obligation and thus may sell their used water to a reclamation enterprise if desired. It will also be necessary to protect consumers of reclaimed water against improper treatment, negligence, etc.

Some of the waste water reclamation projects in the U.S. are meeting with success, for example, the Amarillo projects described by Scherer[24] and Alexander.[25] Alexander describes the effect of nitrates, chlorides, phosphates, detergents, slime and algae.

Water Rights and Water Laws

The subject of water rights is very important to both Canadians and Americans, and in fact it may be necessary to maintain a considerable amount of similarity in the two sets of water laws owing to the geographic, climatic and hydrologic relationships, even if we choose to ignore the social and industrial similarities.

The current interest in water laws stems from the increasing shortages and demands in addition to the inadequacy of many existing water laws. Smith[26] lists some of the causes for concern, such as the failure of common law to provide adequate protection for established uses and from consumptive uses and diversions; common law also may permit surplus water to be underdeveloped. In addition, there is considerable concern because of the present failure of law to curb the destruction of water resources by pollution and over-use.

The great needs for modern water legislation are to provide protection and economic stability, encourage economic development and insure good distribution of supplies, having in mind the hydrologic and other natural laws. This includes the need to provide protection of quality (temperature, chemical and bacteriological) and recreational facilities. The basic problem will be the constitutionality of the proposed law, but this must be overcome, because even in the eastern part of the continent where the average annual preciptation is nearly twice the amount in the west, the great demands are creating significant problems.

It is easy to see that governments will not be able to overcome all the difficulties by legislation, and in fact statutory controls might easily be guilty of such faults as inflexibility, bias towards some uses, awkwardness (if the permit system is not streamlined), subjection to administrative indescretion, and high cost of operation.

Taylor,[27] discussing the proposed Model Water Use Act, prepared by the Law School of the University of Michigan, explained that the Act attempts to approach uniformity and also to incorporate the best features of various State and Local Laws. This Act aims at comprehensive and paramount control over water resources.

Piper[20] presents some interesting hydrologic background in favour of the proposed Model Water Use Act; he takes the attitude that it is hydrologically incorrect to differentiate between riparians and nonriparians or between ground and surface water. Piper states that society must adopt and then apply properly, selected aspects of the appropriation doctrine, permit system and the improvement-district philosophy, all coupled with wide education about the facts of hydrology.

There seems to be a very pressing need to examine our Canadian Water Laws from coast to coast, extending the work of Gisvold.[19] Such a study might consider and weigh the existing laws against the principles and doctrines that actually do exist in the water field today. It seems that the study would be concerned with such doctrines as Riparian Common Law of Natural Flow,[28] Riparian Common Law of Reasonable Use,[29] Correlative Rights, Comparative Injury, Prescriptive Rights, Prior Appropriation and Police Power (licensing). It seems particularly necessary to study the possibility of substituting the words, "of economic importance" instead of "Navigable Streams", wherever the impossibility of navigation is taken as license to mistreat or mismanage a stream.

Gisvold points out that lawmakers do not want to be unnecessarily restrictive and that laws should be kept simple. However, water is used for a variety of purposes, which creates a multitude of conflicting interests and results in complex water laws. Furthermore, water as property has the characteristic of being able to inflict serious damage on neighbours unless it is properly handled. As examples, dams can break, streams and springs can be denied to downstream users by overuse or wastage upstream, and water can be polluted to a serious and even to a dangerous degree. As Thomas[13] points out, it is as logical to advocate restrictions on water uses as it is to restrict other kinds of property. Our present-day economy demands ordinances and laws that govern building heights, noise levels, location of commerce and industry in zones, etc. Owners submit to these restrictions in return for such provision as police and fire protection. Therefore, it is also logical to regulate water uses that affect pollution and supply and to expect these regulations to change as conditions become more critical.

The Water Resources and Water Rights Acts of Alberta, Saskatchewan and Manitoba seem to be guided by a sound principle. Except for domestic purposes, the use of water is not to be decided by the adjoining landowners but by an administrative body according to the most beneficial use. We must realize though, that any proposed administrative Water-Law machinery, requires for proper performance: full understanding of the hydrological principles and informed public that knows what it wants and the consequences, both now and in the future, having fully considered economic stability, conservation, health, recreation and aesthetic values.

The Pollution Picture

A great deal of the foregoing has dealt with water pollution as it affects our water resources, the water supply problems, re-using of water and our modern concepts of conservation. Now having examined the needs of society and realized the urgency of dealing with pollution, we shall look at the pollution problem in greater detail.

There has been a scarcity of literature about our Canadian problems by comparison with the U.S. and England. However, it is quite evident from the work of the Ontario Water Resources Commission in South Western Ontario that our Canadian situation is very similar to that in the U.S. Piche,[30] Allard,[31] and later the Ontario Department of Health[32] all reported that the Ottawa river is seriously polluted, with several places having coliform counts far in excess of the Ontario objective MPN 2400/100 ml. It was noted that even in seriously polluted parts of the river, the appearance was not unsightly; in fact the river might seem clean until scientific measurements are applied. In the same report, Dr. Allard also showed the pathetically heavy pollution that exists in Lake St. Louis and in the St. Francis river.

Similar work has shown that pollution from domestic and industrial wastes is serious at Winnipeg, Regina, Calgary, Edmonton and Vancouver, and recently the work being done in New Brunswick is proving the contention that Canadians are involved in pollution from Coast to Coast. Stream pollution must be controlled because stream beds are our natural piping systems which we must keep in good working order.

Regarding the International aspect of pollution, we are already working with the United States on the Columbia river system and in the Lake Huron-Lake St. Clair area, St. Lawrence River and elsewhere. In addition we are very mindful of the desires of Chicago to ease their sewage problem by diverting water from the Great Lakes to the Illinois Waterway. Hurwitz and Barnett[33] have shown that Chicago must either divert more water or build more sewage plants.

Recently Dennis[34] reported on a very serious epidemic of infectious Hepatitis that occurred in Delhi, India in 1956 and again in 1958. This epidemic has an important lesson for the Western world. In Delhi, routine water analyses were being obtained which should have provided sufficient warning. It was apparently a clear case of apathetic control, lack of hour to hour alertness, administrative jealousy and competition and failure to take action promptly. These are ever-present dangers to public health.

In the western world, we have many additional pollution problems because our progress in water pollution abatement has been far outdistanced by the speed of industrial and technical progress in other fields. Hollis[35] states that we are no longer able to blame complex organic pollutants entirely on industry. There are small quantities of these complex materials, which break down slowly, if at all, resulting from the use of chemicals in every phase of life—home, business and industry. Sewage should no longer be called "domestic" but rather "municipal".

Problems of Sewage and Sewage Treatment

Suspended solids have been a problem in sewage effluents for a long time because of unsightliness, effect on photosynthesis, effect on benthic organisms and their effect on the self-purification capacity of streams. Unfortunately, there is at present no rational way to prescribe the degree to which suspended solids must be removed from waste water in order to prevent unreasonable impairment of a stream.

Photosynthesis is a biochemical process which catalyses a reaction between carbon dioxide, certain organic nutrients and such chlorophyll-bearing microorganisms as algae. The oxygen liberated as a by-product of photosynthesis is frequently the chief source of dissolved oxygen in streams. Photosynthesis is fully dependent upon the intensity of the sunlight which penetrates the water. Benthic organisms are such as fungi, protozoa, rotifers and nematodes which exist in a thin film on the bottom of streams, helping to keep the stream purified and preserve the natural balance; they are easily smothered by settling solids.

Suspended solids have a considerable effect upon the beauty of water. Future generations will miss a great deal if we fail to consider the aesthetic side of this work, but it is necessary to be practical. There are some streams that never have been sparkling clear even before the country was settled. Further, along practical lines, it is necessary to examine the aquatic biologists' contention that suspended solids are the main reason for fish-kills; fish have sometimes been prolific in heavily silted rivers. Also there can be no doubt of the disasterous effect of toxic substances on fish and other stream life; toxicity is a serious problem both during and after the sewage treatment process and if sewage is discharged untreated. The agricultural use of insecticides and herbicides has resulted in one of our worst pollution problems. These chemicals are sometimes dumped indiscriminately or applied carelessly. Sometimes complex organic chemical wastes and other less complex but strongly toxic wastes can be handled in sewage treatment plants by good mixing with large quantities of domestic type wastes. Generally, however, modern sewage treatment methods do not remove these materials.

Detergents are regarded as a serious problem because of the frothing in sewage plants, in streams, and because 3 to 5 mgl may interfere with flocculation and coagulation in water treatment plants. They increase stream algae problems due to their phosphorous content. In addition, chlorination may produce unpleasant odours in the presence of detergents.[12] We know that commercial alkyl benzene sulphonate, the main surfactant in modern detergents, is not readily broken down by the activated sludge process. However, McKinney and Symons[36] claim that the structure of ABS is open to bacterial attack; they think complete degradation is blocked only by a quarternary carbon in the side chain. Detergents are not toxic to either aerobic or anaerobic bacteria. All detergents are subject to biological breakdown except ABS.

For some time the leading sewage experts have been warning us that sewage must have better treatment to reduce nitrates and phosphates which, in turn, promote algae. There are certain advantages to algae such as promoting reoxygenation by photosynthesis, mineralization and production of a food chain. The disadvantages are algae-toxicity, odours and B.O.D. when the crop dies. At present the disadvantages far outweigh the advantages, hence we have the problem of nutrients in sewage plant effluents. Both nitrogen and phosphate are required for the proper functioning of biological processes. Amino acids, ammonia and proteins are all required by the bacteria. The difficulty arises when the bacteria fail to remove enough of these fertilizer type nutrients. (Incidentally, primary treatment only removes about 25% of the total nitrogen and 55% of the phosphorus. Coagulation and flocculation will increase these percentages.)

Radioactivity has created a new problem a new problem for our society. Many radionuclides are isotopes of elements of biological importance and enter into many biochemical processes. This feature spreads radioactivity but on the other hand some radionuclides are accumulated by aquatic life to very high levels. Setter and Russell[37] list such sources of radioactive contamination as industry, medicine, research, mining, processing of uranium ore, nuclear reactors for power production or research, chemical processing of spent reactor elements for the recovery of reactor fuel and fallout from testing nuclear devices.

Pathogenic bacteria, viruses and parasites in treated effluents constitute serious health hazards. For the same reason as stated when discussing reclamation of water, wet sludge appears to be unsuitable for use in fertilizing vegetables, lawns and shrubbery; the ability of viruses and bacteria to travel far in the water table also demands good sewage treatment. Incidentally, little is known about the travel of viruses except that they can travel much further than bacteria; bacteria are limited to about 250 ft. in sandy formations, but travel much further in coarse formations and still further in the water table, according to Ongerth and Harmon.[38]

Many in the past have felt sure that disinfection with chlorine (0.5 p.p.m. combined residual chlorine for 15 minutes) is sufficient to kill pathogenic bacteria. The work of Kelly and Sanderson[39] shows that some methods of treating sewage do not destroy enteroviruses. They found that, depending on pH and temperature, it may require 9 p.p.m. residual chlorine after 15 minutes contact or 0.5 p.p.m. after 4 hr. to kill some viruses.

Clarke and Chang[40] also conducted some extensive work on methods of reducing viruses in water. They recommend prechlorination (ahead of sewage treatment) with a free chlorine residual of 1.0 p.p.m. and 30 minutes contact time and they stress that pH and temperature can both change the time considerably. It was found that flocculation with chemicals is also quite effective; thus it is quite likely that prechlorination encourages flocculation to occur in the settling tanks.

The question of whether to treat industrial waste separately or jointly with community waste, has presented a problem to many municipalities. Some engineers believe that there should be no joint treatment but, except where there are unusual technical problems, it is generally conceded that joint treatment is better from all points of view. There are exceptions to this rule, as for example, where an industry produces an overwhelming percentage of the waste. Whenever an industrial waste is amenable to treatment by a standard type of municipal sewage process, the question of joint treatment can be answered easily if a satisfactory agreement can be drawn. There have also been too many cases where local administrations have gone overboard to coax an industry into town.

Industrial Waste Problems

The technical aspects of industrial wastes are often complex and their solution may require very expensive procedures. In most cases there is not any economical solution. It is only an occasional enterprise for which the recovery aspect of the waste treatment program can be expected to make the project worthwhile economically.

At the same time it seems sound and fair to both industry and the public that the product bear the full cost of production. In this way the economic dead wood can be recognized and cut out. Waste recovery and waste treatment should definitely be part of the process and part of the cost of production.

In addition to these aspects, business enterprise must be able to budget for future costs and also have some idea of its position relative to competitors. It is necessary for industry to know the economic pros and cons of treating or not treating their wastes. A great number of these industrial questions could be answered easily if municipalities would accept the responsibility of putting a price on their requirements for protection of sewers, sewage plants and resources. This could be done by a surcharge system similar to that inaugurated in Winnipeg with their 1957 By-law No. 80.

Waste Treatment facilities are expensive and with many industrial wastes it is necessary to conduct extensive research and pilot plant work on the spot. There are two or three aspects of this that require thought at Government levels. For example, foreign-controlled plants often do all their research in the head office plant; also small plants often cannot afford this development work without tax concessions.

Standards for Sewage Effluents

There has been a lot of work done on this subject and a great deal of discussion has revolved around the concepts of stream standards and effluent standards. It is now generally conceded that both of these sets of standards should be applied on a somewhat local basis, and usually there should be a combination of these standards. The "local" basis may extend to an entire watershed or be confined to a single stream, but it must emphasize that streams differ widely in their capacity to assimilate wastes.

As examples, iron and manganese can be quite toxic to fish under certain conditions,[12] but the toxicity depends on the temperature, dissolved oxygen content, alkalinity, hardness, content of metallic salts, etc. Mixtures of nickel and zinc, copper and zinc or copper and cadmium are much more toxic than the simple salts. Hence the toxicity of each waste must be determined by bio-assay for any given receiving stream. This is also true for such chemicals as phenols and cyanides, although "Oransco"[12] suggest certain limits which they consider unsafe for these chemicals, again stressing the need for more basic research on phenols and bio-assays for a given stream receiving cyanides.

Weiss[41] has done considerable work along these lines on the toxicity or organic phosphorous insecticides. He has been able to show *in vivo*, the inactivation of fish brain acetylcholinesterase (A. Ch. E.) by these insecticides.

Government Activities

The work of the Ontario Water Resources Commission and of the International Joint Commission has generally been along the lines which are supported by this paper. The Water Resources program[42] in Ontario has been outstanding and this program is unique in the water and sewage field, being comparable to any, and better than most programs of this nature, anywhere.

In the United States, the overriding Federal authority that is provided under Public Laws 410, 845 and 660 has been of vital importance in getting essential work done between States and on a country-wide basis, although the primary responsibility rests with the individual States.

In Canada, overriding Dominion legislation also seems absolutely essential. This country should not be overly concerned with losses of autonomy at the local and provincial levels, because we do not have the same written constitutional set up as in the United States. Surely the desired flexibility can be maintained, and if not, loss of some autonomy is a small price to pay for protected water resources.

The Government must consider, that left to their own devices most municipalities, large and small, fail to develop a sensible water or sewage policy until it is too late to avoid hurting themselves or their neighbours. Often the delays result from lack of financing. Sometimes communities could join forces on these projects if senior Governments made this possible.

Sometimes, when several authorities have water and pollution control powers that overlap in a given watershed there will be differences in the ordinances or in the administration that tend to nullify the efforts of all. Considerations such as these plus a sound research and development program are quite properly the work of the Dominion Government, even if some constitutional problems must be solved first.

Research & Development Program

In explaining the need for more research on water problems, Burney[43] made some statements about the U.S. that are also significant to Canadians. He referred to the tremendous need for a speeded-up program to fight water pollution, and expressed his distaste for the "crash" program that certainly lies ahead. Burney says the U.S. is very close to the time for 100% removal of pollutants from sewage.

We are dedicated to economic growth and we foresee huge population increases yet we still delay the planning and production of essential goods and services until the lack of them creates enormous problems.

Basic knowledge is not keeping pace with the development of the problems and pollution control becomes a series of actions based on expediency rather than a planned program. Facts are needed to justify the huge expenditures that are being, or will be proposed for water resource and sewage programs. Someone should be given the responsibility to present our Government with a well defined, long range research and development plan and an inventory of the problems for consideration at the highest level.

In the U.S. even after 12 years of feverish activity, they now realize that they are embarking on gigantic water projects with alarming gaps in their knowledge of the things they seek to control. The actual limit of error or ignorance is seldom less than 25%, according to Boyce.[44]

In conclusion, the following list of research projects is presented as a possible nucleus for a Dominion Government program, under the leadership of a well organized, effective Water Pollution Control Board. (This includes the formation of a committee, representative of all interests in this field.)

1. Establish engineering parameters which will continuously assess the total pollution and the actual state of our water resources;
2. Probe for new methods of waste treatment geared to remove any and all contaminants;
3. Evaluate the health and economic aspects to crystallize public opinion and establish a basis for a national policy;
4. Develop adequate hydrologic, geologic and geographic data, coordinating these data into a nation-wide scheme. Make an inventory of our total water resources using drillers' reports, etc;
5. Set up a comprehensive watershed research program to learn the effects of logging, farming, recreation, construction and other activities on the quality of water;
6. Collect reliable basic data on water usage by industry and by region from coast to coast, including a detailed survey of selected industries;

7. Investigate the individual and composite effects of the many complex substances that are polluting air and water. This includes a study of agricultural chemicals and how these are handled, surfactants such as alkyl benzene sulfonate, phenols, cyanides, and others. The studies should be concerned with methods of treatment and the establishing of safe limits under continuous exposure.

8. Further evaluate the effect of suspended solids on benthic organisms in conjunction with such American workers as Hoak;[45] then set rational limits;

9. Set up a program for monitoring and releasing radioactive wastes. As suggested by McCallum,[46] measure alpha and beta radiation for both suspended and dissolved solids and then determine better treatment methods. Determine the safe levels for aquatic life by finding: the concentration factors of the critical radioisotopes; organs or tissue which accumulate radioactivity; the most sensitive stages in the lives of marine biology; the method by which organisms assimilate radioactive materials;

10. Evaluate oxidation (stabilization) ponds particularly for various Canadian regions; establish their effects on ground water; establish their effect on pathogenic bacteria and viruses. Where they can be safely used, establish reliable design criteria and especially ascertain the design relationships between B.O.D. loading, volume, depth and desired degree of treatment. Establish any other limitations such as types of wastes;

11. Establish the inactivation of pathogenic organisms that is obtained by all the modern recognized methods of treating sewage and handling sludge. Determine the minimum disinfection required for each method;

12. Study the travel of pathogenic bacteria and viruses in the water table and in various formations;

13. Obtain full data on areas using septic tanks, methods of construction, laying of tile, proximity to wells and the effect with time on these wells;

14. Assist industry in the study of their problems, realizing that many industrial waste problems are highly complex and may require a combination of industrial and sanitary engineering skills;

15. Conduct oceanography studies as related to waste disposal, including a study of salt water intrusion of ground water resources;

16. Estabish the purification capacity and water quality criteria for all rivers and streams of economic importance.

Acknowledgment

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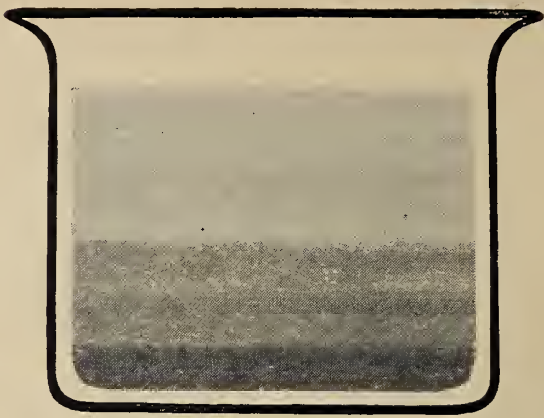
THE MEASUREMENT OF INDUSTRIAL WATER POLLUTION



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Chemically pure water does not exist in the natural state. The liquid popularly called water is a dilute aqueous solution of many substances. Some of these impurities are essential if the water is to support life or be palatable, some are innocuous but not essential, some are harmful if present in more than certain concentrations. Since so-called pure or unpolluted water contains many other substances, pollution is only measurable as a degree of divergence from some arbitrary standard. Before pollution can be measured it must be defined. Probably the best general definition of water pollution is "some artificial change in a body of natural water which detrimentally affects a beneficial use". As this paper deals with the measurement of industrial water pollution and bacterial pollution is more generally the result of domestic pollution, consideration of this rather specialized aspect of pollution will be omitted. It deals, therefore, with the measurement of pollution other than bacterial pollution in the forms usually resulting from industrial activity. Because potential sources of pollution are manifold and the variety of substances involved very large and ever increasing, many of the procedures used for measuring pollution measure effects rather than the substances responsible. A few of the most common types of measurement of pollution will be discussed and appraised, with special reference to those tests which measure effects.

Biochemical Oxygen Demand

THE B.O.D. test is procedurally simple, but the correct interpretation of the results often requires considerable skill and experience. Briefly, the test consists of enclosing a sample of water in an airtight bottle, incubating it at 20°C for five days and measuring the amount of dissolved oxygen present before and after incubation. The difference is the B.O.D. figure and is most simply expressed as parts per million or milligrams per litre. In practice there are several refinements which have to be used to ensure accurate results but this description is adequate for the present purpose.

The test is intended primarily to measure two things, first, the amount of assimilable organic matter present in the water and secondly, the deoxygenating effect of it on the water. A very wide range of organic materials when present in aqueous solutions are chemically broken down by the action of micro-organisms in the water to carbon dioxide and water. In the process dissolved oxygen is removed from the water by chemical combination with the carbon and hydrogen atoms. If there is no source of replacement oxygen, (as in an airtight bottle) the amount of dissolved oxygen is reduced.

It has been demonstrated experimentally that if an assimilable organic material is present in water with an adequate supply of dissolved oxygen and suitable micro-organisms at 20°C for five days, 68% of the total amount of the organic matter present will be destroyed. If, therefore, the conditions of the experiment are met, the amount of oxygen used up will be a measure of the amount of the assimilative organic material originally present. It is not necessary to know the composition of the organic material, nor does it matter that a complex mixture of organic substances is present. As long as the materials are assimilable by the micro-organisms present, the test will be valid.

It might be thought that the matching of organisms to materials is very complex. In the case of certain substances — particularly synthetic organics — this is true, but micro-organisms are remarkably versatile in their activity and it will usually be found that if an organic material has been present in a body of natural water for a reasonable period (a month or more) there will be micro-organisms in that water capable of breaking it down.

Given normal conditions, therefore, the B.O.D. test gives a measure of the assimilable organic material present and it also gives a measure of the amount of dissolved oxygen this material can be expected to remove from the water. Excluding toxic effects this capacity for removing dissolved oxygen is the most important pollutional effect of organic materials, for the oxygen is essential for the maintenance of fish and other live forms and also for the avoidance of nuisance conditions. Where all or nearly all the dissolved oxygen is removed from water a new group of organisms (anaerobes) take over. These live by breaking sulphate down to sulphide, which results in the stinking condition of badly polluted waters.

The principal shortcomings of the B.O.D. test are first, the effects of toxicity and secondly of non-assimilative organics. If toxic materials are present in the water these will inhibit the activity of micro-organisms in the test and an erroneously low result will be obtained. With experience this can sometimes be detected by judicious dilution or other means but in some cases it invalidates the test under good conditions. In inexperienced hands it can lead to very considerable errors. The organic contaminants in the stream or lake are still in the water and generally a point will be reached where the toxicity is no longer inhibitory and then the full effect of the organic materials will be released.

The synthetic detergents are a common example of unassimilable organics. These materials are not easily attacked by micro-organisms so that they do not register in B.O.D. tests and for the same reasons they are not destroyed in biological treatment processes. This gives rise to the foaming problems which have occurred in many natural waters, as well as in treatment plants, since the introduction of these materials.

Fig. 1a and 1b show the effects of both toxic materials and non-assimilable organics on B.O.D. results.

Fig. 1a shows what happens when conditions are unfavourable for assimilation of organics due to unfavourable pH, presence of toxic materials or other reasons. The readily available food is used more slowly than normally and even when used is only converted to cell substance and absorbed material. After five days less than 50% has been utilised. Fig. 1b shows what happens under favourable conditions. The available material is quickly converted to cell substance and even this is then utilised. Even some of the exotic food is converted. In the five day period about 68% of the original material has been utilised.

Oxygen Sag Curves

The consideration of oxygen sag curves follows directly out of that of B.O.D. In natural waters the breakdown of organics is taking place continuously, using up dissolved oxygen. Under normal conditions the oxygen is replaced by the processes of reaeration — transfer through the surface, turbulence, photosynthesis — and a state of equilibrium exists. If the organic load is steadily increased the rate of use of dissolved oxygen will at some point exceed the reaeration capacity, the equilibrium will be upset and the concentration of dissolved oxygen will drop. If the load is sufficiently heavy all the oxygen may be removed.

The processes of decomposition are continuing, however, and at some point sufficient organic material will have been destroyed to allow the reoxygenation processes to gain ascendancy. The amount of dissolved oxygen then increases until a new state of equilibrium is reached.

This state of affairs can be demonstrated in any river having a severe pollution of organic contaminants, by taking a series of dissolved oxygen measurements downstream, starting above the source of pollution and proceeding down at intervals to a point where complete recovery is found.

Fig. 3 shows the results of one such series of observations, the graphical illustration of which is termed an oxygen sag curve. These results are from the river Thames in England.

The oxygen sag is a valuable measure of pollutional effect on a river. It demonstrates in graphic form one important aspect of the pollution. For a complete picture, however, curves must be prepared for different times and conditions. Water temperatures, river flow, turbulence and fluctuations in pollution load, all affect the oxygen sag curve and these variations should be known. Lowering the temperature has the effect of reducing the severity of the drop in dissolved oxygen but increasing the duration of the effect —a longer stretch of river is affected, but less critically.

Toxicity

Chemicals vary greatly in their toxic effects to life forms. Some, such as cyanide, mercury and zinc are lethal to most living material at concentrations of less than one part per million. Others, such as ammonia, phenol, and some synthetic detergents are lethal in fairly low concentrations — approximately 10-30 p.p.m. Other materials are only toxic if present in comparatively strong solution.

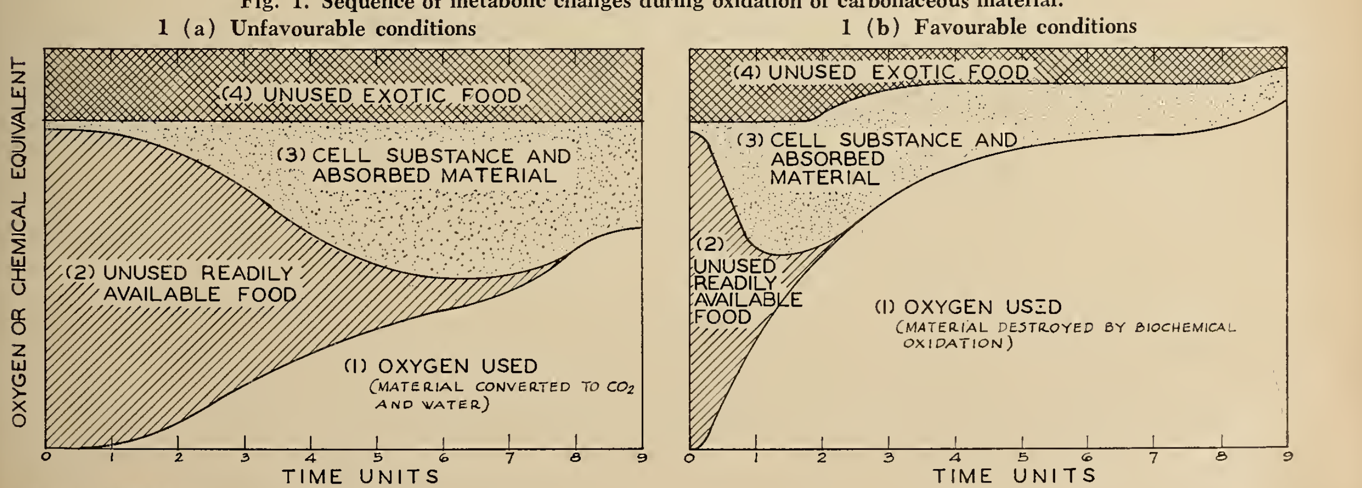
Not only do different substances vary in their degree of toxic effect, but the effect of any one substance varies with the type of organisms on which it is tested, the other properties of the water (pH, presence of other toxic materials), temperature, amount of dissolved oxygen present, and whether there has been a period of acclimatisation. Even individuals within a species vary considerably in their tolerance of most substances.

In some cases it is comparatively easy to analyse water directly for toxic materials, e.g. in the case of most of the heavy metals and some radicals such as cyanide and phenols. Often, however, analysis is difficult and time consuming as with many organic materials and, where complex mixtures are involved, either impossible at present or only possible by considerable expenditure of time and effort by specialists. Even when the content of water is known it is often difficult to assess its effect, because of the many variables; e.g. copper and zinc, if present together, increase each others toxicity, (synergism); ammonia and carbon dioxide reduce the combined toxicity (antagonism). The toxicity of some substances is critically[1] affected by pH; e.g. a decrease in pH from 9 to 8 decreases toxicity of ammonia about eightfold.

For these reasons the most practical course is generally to make a direct measurement of toxicity without isolating the toxic materials. This is generally referred to as a "Toxicity Test" or "Bio-assay".

As with the B.O.D. test, the procedure for a toxicity test is fairly simple, but care and understanding is required for a correct interpretation of the results. In its simplest form a toxicity test or bio-assay consists of exposing one or more of the test animals to known concentrations of the

Fig. 1. Sequence of metabolic changes during oxidation of carbonaceous material.



material being tested and observing the time taken to kill the animal. Unfortunately for simplicity, living material is never uniform and therefore many precautions are necessary if the results are to be intelligible. Among the variations most commonly met in toxicity tests are:

1. Variations due to temperature;
2. Variations due to difference in size or age of test animal;
3. Variations between individual animals of the same species;
4. Variations in chemistry of the dilution water;
5. Variations in oxygen concentration.

Some of these variables can be eliminated by care in the procedure —e.g. animals of the same species and within certain limits of age and size can be used. Even when this is done with great care there will still be considerable variation between individuals. Herbert[2] has shown that the time taken to kill 42 individual rainbow trout, carefully selected for identity of size and age, with 0.14 p.p.m. of cyanide, varied from 29 to 207 minutes. In spite of this, if a suitably large sample is used, the time to kill the majority will show much smaller spread and a reliable mean value can be obtained. It is necessary, however, to use a sufficiently large sample to obtain a reliable mean.

Temperature can be controlled fairly easily and this should always be done in toxicity tests.

Dissolved oxygen can be controlled by passing air or oxygen through the test solutions, but care is necessary to avoid removing volatiles which may significantly affect the results. The best method of maintaining dissolved oxygen is to use continuous flow apparatus. Hitherto this has been difficult and complicated, but a suitable continuous flow apparatus has been developed which should make this method available more easily.

Problems connected with dilution water are best dealt with by using water from the location under test, if this is possible. Differences in pH, hardness, buffer and other chemical characteristics of the water are so important and often so difficult to allow for in the results, that this is the best practical solution to this problem.

The results of a toxicity test may be in one or more of several forms. They may be represented as a concentration which has been found in experiment to kill 50% of the test animals in either 24, 48 or 96 hours. This is called a median tolerance limit, abbreviated to TLm. This is the usual method of expressing results in

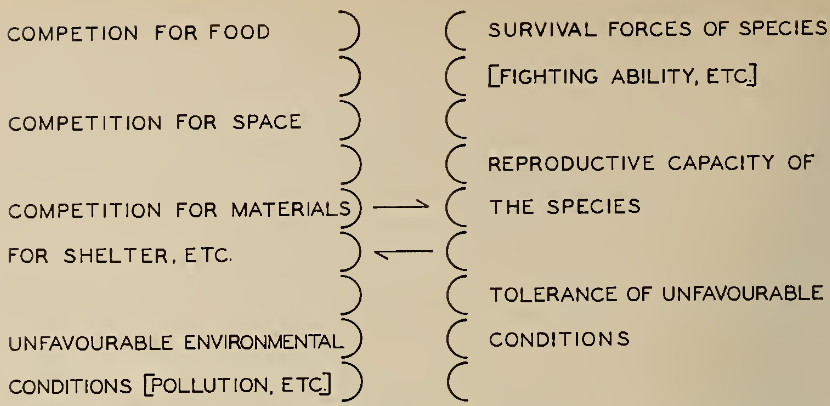


Fig. 2. Diagram illustrating the equilibrium of some of the environmental stresses acting upon each species in a community and the survival potentials which oppose them.

North America. Some European workers, particularly those concerned with fundamental research on toxicity, derive a relationship between concentration of test substance and median survival time at various concentrations. These are but two of several methods which have been used to express the results of toxicity tests.

Whatever method is used, the experimental results show the concentration of test substances which kills fish. In practice one requires to know the concentrations which will not kill fish. The derivation of the latter from the former is a matter of some difficulty and often controversy. The methods used are not suitable for discussion in a general paper of this kind, but it can be stated that it is possible to derive a result which can be used for design[3] data and other practical purposes.

A valuable application of the toxicity test has been developed by Henderson and Tarzwell.[3] They have derived a function called dilution volume, which is the dilution necessary to reduce the whole of a toxic effluent to a concentration which will kill 50% of the test fish.

$$\text{Dilution volume} = \text{Effluent Flow}\ \frac{100 - \text{TLm}}{\text{TLm}}$$

If an effluent is made up of a number of different effluents, the dilution volumes of the components are additive in the total effluent.

Biological Measurement of Pollution

Chemical analysis is and will probably continue to be an important part of the measurement of pollution, but it seldom gives a complete picture, nor is it always the most economical method. Of at least equal importance, although as yet less widely used, is the direct measurement of pollution by biological surveys.

Although this method is of great importance in assessing the effect of pollution on fisheries, it is by no means limited to this application. The effect of pollution on the organisms normally living in the natural waters is a good general measure of pollution. Although there is a quantitative difference between the standards of pollution affecting different uses, they are, with certain exceptions, parallel, and the biological measure of pollution supplies a good general yard stick.

The basis of this method of measuring pollution is that in any body of natural water in the unpolluted state there will be a community of animals and plants which will be typical of that environment. The species represented and the numbers of individuals varies according to the environmental factors, such as, temperature, water movement, season, type of bottom etc., but a state of equilibrium exists at any time. If a change takes place in the environment, such as pollution of the water, the equilibrium will be upset and the qualitative and quantitative composition of the community will change. It is by measuring this change in composition of the community that a measure of pollution is obtained.

Fig. 2 sets out a few of the forces which affect the state of equilibrium of a single species with its environment at any time. If one can imagine a complex system in which there is interaction between the equilibrium of all the species within the community, some idea can be obtained of the mechanics of the system.

If a new stress, such as added pollution, is imposed on a community in equilibrium, it will upset the equilibrium, because different species vary in their tolerance of pollution and their ability to withstand it. The new factor will push the balance against the intolerant species, but because this reduces competition for food it may favour more tolerant species. As a result some species will decrease in numbers, some will increase.

It is important to note that in using this method for measuring pollution we are using the change in

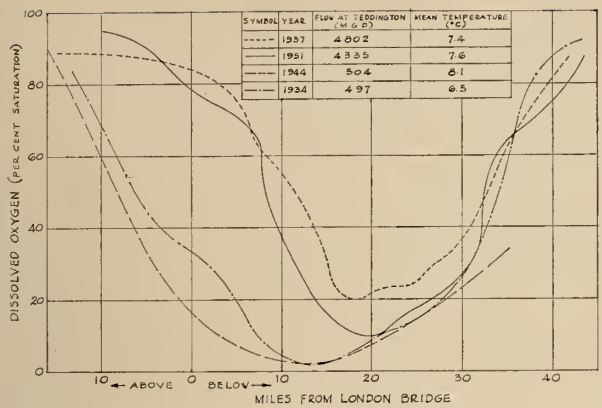


Fig. 3. Oxygen sag curves, for River Thames, England.

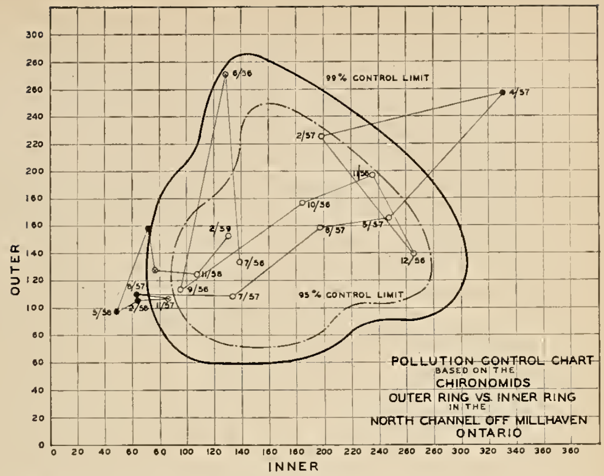


Fig. 4. Chironomid control chart developed from inner and outer rings of samples taken at Millhaven, Ontario, July 1956 to February 1959.

community as the measure of pollution effect. In this way we eliminate the difficulties inherent in trying to establish in absolute terms the composition of a normal community.

This method can be used to monitor changes in pollution, as when a new plant is put into an area and it is desired to check whether the plant has any pollutional effects on the water to which its effluent is discharged. It can also be used to measure the extent, if any, of pollution at existing plant locations.

The first application is illustrated by the work I have done in co-operation with the company's staff at the C.I.L. plant at Millhaven in Ontario.[4] Here a new chemical plant was located on a part of Lake Ontario with high recreational and amenity value. It was essential not only to make provision for proper treatment of all effluents to make them innocuous, but to check that the treatment was effective.

Briefly, the method consisted in making biological surveys and from the data constructing biological control charts which prescribed the limits within which different components of the biological community varied under normal conditions, before the plant commenced operations. By continuing the surveys from time to time after operations commenced it was possible to check whether any changes outside the normal variations had taken place.

Fig. 4 shows one of these control charts. It will be seen that in the period August 1957 to January 1958 the chart showed a definite trend out of control limits. When this was observed investigations were made in the plant and eventually the cause, which was an unknown leak in a storage facility, was discovered. When this was remedied, the chart showed a return within control limits. The single point outside the 99% limits in April 1957 was not a trend, but an isolated observation outside control limits.

This type of application shows how this method can be used to discover an incipient pollution long before it reaches nuisance proportions. The method requires a fair amount of pre-operational survey work, but once the control charts have been set up, a comparatively small expenditure of time and money enables a very close check to be kept.

The second application has probably been more widely used, but the results are not often published. One reason for this is that this work is sometimes carried out where there is a pollution problem and publication of detailed results might incriminate the parties concerned. For this reason a great deal of data remains in the files of companies, control agencies and consultants. It is to be hoped, however, that as cases are cleared up and the data is no longer incriminating, it may be possible to publish the results.

The principle is the same as in the first application except that in this case the changes have already taken place before the survey commences. It is not, therefore, possible to get an exact datum for conditions prior to change. This difficulty is overcome by finding some locations upstream and if possible some downstream which resemble as closely as possible the polluted zone, but are out of the influence of the pollution. These unpolluted zones are used as controls and replace the pre-pollution datum of the first application. The communities of animals and plants in these communities are then compared with those of similar locations in the pollution zone and the differences used to measure the degree of pollution.

The method of illustrating results is still the subject of research. The author has used a method based on an arbitrary scoring system.[5] In this system the organisms found in the normal and polluted parts of the area under study are put into 3 or 4 groups according to their known or estimated tolerance of the type of pollution being investigated. One such grouping is given in reference.[5] The group 1 organisms are those known to be very tolerant of pollution, the group 2 organisms those of moderate tolerance, the group 3 organisms those of slight tolerance and the group 4 organisms those known to be intolerant.

Group 4	Group 3
Intolerant of Pollution	Slightly tolerant
Score 4 points	Score 3 points
Group 2	**Group 1**
Moderately tolerant	Tolerant
Score 2 points	Score 1 point

The organisms found at each location are listed under the group to which they are known or believed to belong. A score is then allotted to each location according to whether organisms of the various groups are present. For example:

- A location with only group 1 organism, a score of 1;
- A location with group 1 and 2 organisms, a score of 3;
- A location with group 1, 2, and 3 organisms, a score of 6;
- A location with group 1, 2, 3, and 4 organisms, a score of 10.

It will be found that, if the organisms have been correctly allotted to groups according to pollution, and if pollution is the only variable factor between the locations, a station which has group 3 organisms will also contain group 2 and 1 organisms and one with group 4 organisms will contain 3, 2 and 1. In practice some allowance is also made for numbers of organisms — e.g. if in the control location there are 10-50 individuals per sq. ft. of a group 4 species, and at another location one individual is found in a few samples, one point and not 4 will be allotted for it, as it appears that the species has only a precarious foothold at this location.

When the results have been set out in this form, each location has a score. This score can then be illustrated graphically as in figure 5. This is a fictitious example, but it is based on results I have obtained in the field.

It is not claimed that this method of illustrating results is quantitative in that a biological score of 5 corresponds with 50% pollution, but from experience I consider that the picture of results as illustrated in this way is in good general agreement with other observations about the pollution; e.g. in pollution where dissolved oxygen is an important factor, the graph of biological score will be in good general agreement with the oxygen sag curve.

One shortcoming of the method is the lack of published data on the tolerance to pollution of any species. An experienced biologist in this field is able to place most of the species he finds in one of the groups with reasonable confidence, but this experience has not generally been put into the literature, so that it is not readily available to other workers. Even an experienced worker often finds difficulty in distinguishing between organisms of Group 2 and 3. In some cases, I have found it better to combine these groups, and then have only 3 groups and allot scores of 1, 2 and 3 with a maximum of 6 if all groups are present. This makes the resultant graphical illustration less sensitive, but eliminates error where I am uncertain of the tolerance of the intermediate species. If sufficient research were done on the pollution tolerance of various species this difficulty could be largely eliminated.

An important application of this method, apart from the assessment of the degree of pollution existing at a particular time, is as a measure of changes taking place in a body of natural water from time to time. It may be that it is desired to know whether the pollution is getting gradually worse as industry and population increases, or to assess whether remedial measures are being effective in reducing pollution. To make such an assessment by chemical surveys is difficult and involves a very extensive program of sampling, because the day to day, week to week and month to month variation in chemical constituents of natural waters is considerable. The biological survey, however, reflects the overall condition and results do not fluctuate with short term changes to anything like the same degree as the chemical content. For this reason surveys carried out annually, biannually or quarterly will show a trend if one is present. In this case the fact that the graphical illustration may not be quantitatively accurate is not too significant, as long as the methods used in deriving it are consistent. A series of curves will be obtained such as in Fig. 6 and these will indicate a definite change in the pollution status of the water. For example, the continuous line (May 1957) shows the score for conditions found on that date. Improvements were made at the plant during the summer of 1957 and 1958 and these improvements were reflected in the curves for May 1958 and May 1959, which show a higher score at several points downstream of the plant.

Conclusions

The methods of measurement of industrial pollution described and discussed in this paper by no means cover the whole field of pollution measurement.

The chemical analysis of water is well described in several text books which deal specifically with the subject. The methods described in this paper are mostly concerned with the measurement of pollution effects. These are not so well described nor their interpretation so widely understood. Their value lies in the fact that they measure directly the effects of pollution in which we are most often interested. They do not require the same degree of interpretation as when the water is analysed for specific chemicals.

No two cases of water pollution require exactly the same combination of methods of measurement. An optimum pollution measurement program must be designed especially for the circumstances. Seldom is it economically possible to make all the measurements which would ideally be required and usually a compromise must be struck. In this case the value of the results will largely depend on how successful the planners of the program are in estimating which methods to include and which to omit. As in many similar situations in engineering, experience is a big factor in the correct assessment of importance and there is really no adequate substitute for such experience.

Acknowledgements

Fig. 1, Courtesy of Industrial and Engineering Chemistry. Fig. 2, Courtesy of A. L. M. Gameson and W. S. Preddy. Fig. 4, Copyright 1959. Reprinted with permission from Vol. 31., No. 12, Sewage & Industrial Wastes, Washington, D.C.

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Fig. 5. Diagram illustrating how biological score will vary above and below a source of severe pollution.

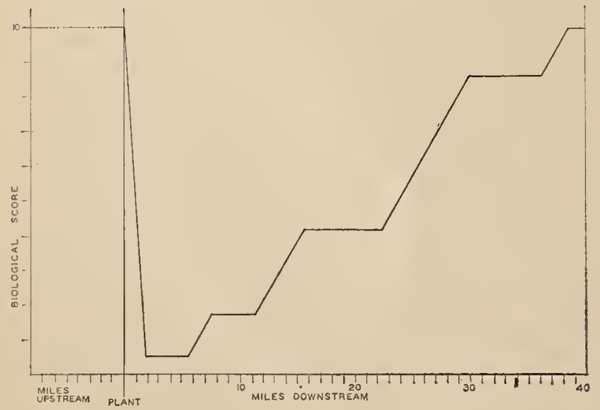
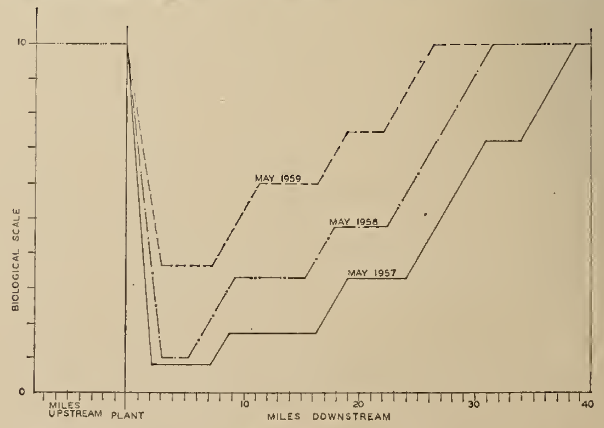


Fig. 6. Diagram illustrating the changes in the graph of biological score below a source of severe pollution, as the pollution is gradually reduced.



Discussion

ENGINEERING FOR EXPORT

R. A. Frigon, M.E.I.C.,
Chief, Engineering & Equipment Division, Foreign Trade Service, Department of Trade and Commerce, Ottawa.
The Engineering Journal, March 1960, p. 93.

Discussion by C. C. Parker, M.E.I.C.

May I first speak as President of the Consulting Engineers of Canada: A number of our members recently embarked on our first joint venture abroad, the visit to the British W.I. Federation with a display at the Canadian Trade Fairs in Jamaica and Trinidad last January and February.

In this effort we were assisted by Mr. Frigon, indeed he first suggested it. We made many contacts and intend to follow them up. This is in effect a Canadian version of the European Consortium Mr. Frigon has referred to. I agree heartily with his comment that on-site promotion is necessary for consulting engineers and this kind of approach is less costly to the individual firm. It also has another advantage; I found as representative of a group I was welcomed and listened to by many leaders in public office where if representing my own interests alone, I may not have been so well received.

Our association intends to pursue this effort and appreciates the assistance given by the Canadian Government through the Department of Trade & Commerce and their field representatives. Several of our members are engaged in efforts Mr. Frigon has just mentioned.

My own firm's experience is limited to certain Colombo Plan work and indirectly with the work of the World Bank. I would make one observation only with regard to anticipated public works in the underdeveloped countries. European consultants under pre-war colonial administrations were heavily engaged, in the post 2nd world war period under American financial aid. American consultants were likewise very busy and still are. Undoubtedly, there was rich financial return. Such opportunities cannot be expected in the future, for the rise of nationalist aspirations is giving rise to requests for engineering help advising and teaching native engineers. Thus projects which could most efficiently be done in Canadian Consulting Engineers offices must needs be done on site, with as many native engineers as possible employed on the work. This kind of effort will be frustrating and tedious and undoubtedly not as remunerative financially. But accept it we must, for it is the natural result of the spread of our Christian democratic thoughts and of our recent and continuing technical aid programmes.

PLANNING AND CONSTRUCTION OF THE CHUTE-DES-PASSES HYDROELECTRIC POWER PROJECT

F. T. Matthias,
Director of Engineering and Construction, Aluminum Company of Canada Limited, Montreal.
F. J. Travers, M.E.I.C.,
Senior Project Engineer at Chute-des-Passes for H. G. Acres & Co. Ltd., Niagara Falls.
J. W. L. Duncan,
Electrical Engineer,
Aluminum Company of Canada Limited, Isle Maligne.
The Engineering Journal, January 1960 p. 39

Discussion by T. M. Dick, Jr.E.I.C.

The paper presented in the January Journal on the development at Chute-des-Passes made interesting reading covering as it did the development and construction of the whole project.

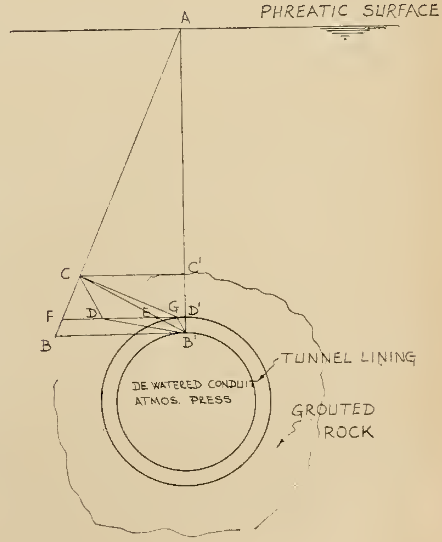
However there are one or two points which I would like to have cleared up. In the first place the authors state that, in places the rock surrounding the tunnel was grouted to prevent excessive external ground water pressure from acting when the tunnel is dewatered. Surely grouting the rock will not accomplish this. Consider the accompanying sketch.

The line AB represents the hydrostatic pressure if there is no flow of water through the grouted rock and concrete lining and the pressure on the tunnel is given by FD^1. When the flow of water develops and the grouted rock has the same permeability as the concrete then the pressure line will follow along ACB^1 and the pressure on the tunnel is represented by ED^1. If the grouted rock has a much higher permeability than the concrete the pressure gradient will follow line $ACBD^1$. The pressure in the tunnel is now given by DD^1 which is not much reduced from the full hydrostatic pressure. The reduction is given by FD.

Lastly if the concrete is extremely pervious compared with the grouted rock then the pressure line will approximately follow $ACGB^1$. In this case the pressure on the tunnel is very small and is represented by GD^1.

It seems reasonable to suggest that the pressure gradient lines ACB^1 and

(Continued on page 155)



Automation and Control Engineering in Canada

Automatic Handling and Storage

IMPROVEMENT of efficiency in industry need not be confined to manufacturing operations. The handling of materials occupies a considerable amount of time in most industrial undertakings and, though its importance varies greatly, it is rarely negligible economically.

Storage of materials may be considered as an intermediate stage in the handling system, for example, between the receipt of raw materials and their release to manufacturing areas or between completion of manufacturing processes and release for shipment. In very few cases is the solution to the problem of storage as simple as this generalized definition.

An ideal storage and handling system for any particular industrial operation can be devised only by considering all the variable factors involved. These may include, in addition to basic data about the type of material to be handled, such items as the best type of building, various methods of handling, best use of space, and the type of equipment. In addition to all this is the question of how much automation should be applied to the whole operation.

Obviously there is an economic limit to any particular project, though there is practically no limit to the availability of suitable types of building, methods, and equipment to perform complex mechanical handling operations. There must also be a limit to the extent to which automation is introduced to replace manual work, though in certain conditions a high degree of automation can lead to considerable savings through increased efficiency. Examples of this are high-speed sorting or selecting operations, or high-volume withdrawal from storage of orders consisting of many different items.

Automatic Operations

In the field of automated storage and handling, many things can be done. A program of operations may be provided, together with the means of carrying out these operations, so that the required materials may be selected, sorted, taken from one place to another, positioned and otherwise handled, together with necessary recording or accounting data.

Programing involves familiar data processing techniques, and the use of punched cards, tapes, and various memory devices. The program instructions are passed on via electrical, mechanical, optical or other systems to operate deflecting, sorting, selecting and various handling mechanisms, in the correct sequence.

Methods exist and equipment is available to select a whole order of mixed items for delivery from storage to manufacturing plant or delivery area with no manual intervention beyond the initial starting of the whole operation. Again, the limitation to what can be achieved is an economic one.

Receipt to Storage

Without considering complicating factors such as breaking down or assembling palletted or cubed lots of several units, which may be done automatically by mechanical equipment, it is possible for an automatic system to sense codes on individual items, space them out on a conveyor, and divert them to storage from any desired point in the system.

Where different items are received, it may be necessary to accumulate items on conveyor lines in an area between receipt and storage, so that they may be identified and then fed sequentially and in like lots to the storage area. Discharge to storage is controlled electrically to avoid mixing by simultaneous feeding from more than one line. A suitable memory system can note the discharge from a particular line and then, at a set time, cause the load to be deflected or otherwise moved to the correct storage position.

Storage

Material actually in storage may also be subject to automatic control, for inventory and accounting purposes. For example, in a central warehouse that handles many mechanical parts, a system of code numbers may be established (one for each part) and transferred to punched cards. The card may include a record of actual quantity of each item, plus a note of the minimum required inventory of that item, and any necessary details of cost, charges, and so on.

When the card is handled by the appropriate data processing equipment, all necessary data are recorded. If inventory has been reduced to the minimum figure, the processing equipment can automatically prepare an order card which is passed to the appropriate department for consideration.

Ordering replacement stock may also be done by means of a form prepared by a punched paper tape or similar device that contains the specifications of the required material or item. In addition to rapid ordering of replacement parts, such a system is able to make a quick financial accounting of the value of stock at any required time.

Removal from Storage

Many similar techniques may be applied to the handling of materials whether they are being moved to or from storage, but the filling of orders consisting of many mixed items, from storage, can pose several interesting problems.

If items from different locations in the storage area have to be fed rapidly in a certain sequence to, say, a moving container in which an order is being collected, a manual operator may have to work within very close limits to avoid missing one of the containers. On the other hand, automatic handling of the same container can avoid such errors. For example, a labelling system can be used to divert the containers sequentially to the various loading points by means of sensing devices that operate the necessary mechanism. Once deflected, the container can be loaded with the necessary items from that particular area, then the labelling device can be reset to indicate the next deflection point, and the container sent on its way along the main conveyor stream.

There exist completely automatic systems that can pick any desired order without manual assistance. These systems require the installation of special storage racks equipped with release mechanisms that allow an item to be fed, on command, from the rack to a conveyor. Obviously, there are many possible forms of mechanical device and method of operation that can be used to obtain the release of the item from storage.

Whatever the mechanism, signals for automatic operation may be initiated by a program stored on punched cards or tape, or magnetic tape. The program may also designate the destination of the item; for example, to a particular loading terminal in the shipping zone.

The program may operate in two ways to direct items to succeeding areas. One method feeds orders in sequence into the system so that storage racks are selected in rotation and a complete order is assembled in a slug on the main conveyor line. The program can be made to leave adequate space between individual orders so that they can be separated at their terminal.

The other method collates several orders and automatically releases the total number of given items needed for all these orders. The individual items are sent in groups to the packing or shipping area, where they are diverted automatically into zones or containers in which the separate orders are to be collected.

Particular Applications

An example of an automatic warehousing system uses static switching for handling a variety of types of product packed in bags of different sizes. Bags arrive from the manufacting area on a main conveyor from which they can be moved to any one of seven transfer conveyors, at the end of which they are assembled and taken to the appropriate storage area.

Where the main line enters the warehouse, an operator at a control console can select the required destination of each bag as it arrives. The sorting signal is fed into the system, which observes the bags as they move along the main conveyor until they reach the correct point for transfer to the selected transfer conveyor. The system is fully protected against nearly all possible sources of error, such as failure of a pilot device or incorrect calling by the operator, say, for two transfers of the one bag. The system will also allow for the case of a transfer conveyor being full and unable to accept a bag.

The different types and sizes of bag arrive at random, so the system has to synchronize the operator's signal with the actual position of the bag on the conveyor. This is done by means of a shift register, into which a different binary coded signal is placed for each of seven inputs fed into a binary coder from the control panel. The signal remains in a select memory bank until the corresponding bag reaches an actuating device on the conveyor system (for example, a photo-electric cell monitor). The signal then shifts to the memory bank of the first transfer conveyor when the bag reaches the monitor for that conveyor. If the bag is to be transferred only at a later conveyor, its signal is shifted from one conveyor memory bank to the next until the correct conveyor is reached, when the coded information is read out and the necessary transfer mechanism is actuated.

When transfer takes place, the signal for that particular bag is no longer needed and is cancelled out from the shift register. The same sequence applies to other bags in the system.

If a monitor should fail, the coded signal for the bag shifts through or is stored until it can move to a clear bank. If the transfer point monitor fails, the signal for the bag is recoded so that the bag is automatically carried on to a collecting point from which it can be removed manually to its correct area. Bags are also sent to this manual collecting point if a transfer conveyor is too full to accept another bag; if the operator fails to select a destination for a bag; or if two signals are selected for the one bag.

In this particular example, a binary code is used to identify the bags. For nine required readouts the system has four memory channels, all of which are used at the start of the operation. At shift register points along the system fewer channels are needed until, at the last readout, only one channel is required.

Parcel Sorting

Rapid sorting of items such as packages to be sent by parcel post can be achieved using a coding system to indicate destination areas. A two-number code is placed as a magnetic spot on a memory drum which rotates and passes the coded spots beneath a series of read heads. The parcel, or parcels with the same code, are placed in containers which move along a conveyor that passes over a series of belts running across the direction of the main conveyor. Each of these belts corresponds to a particular destination.

When the code spots simultaneously energize two reading heads (connected through an AND static switching circuit) the resultant signal causes the parcel to be dumped on the appropriate destination belt.

The memory drum and main conveyor move at different speeds, and the distance travelled between coding and dumping points is the critical measurement. Coding is done exactly at the right time by memory circuits which remain de-energized until the container holding the particular parcel trips a pulse switch; as soon as this happens, a strobotron writing circuit places the spots on the channels of the memory drum.

Static switching was chosen for the dispatch of outputs to the dumping release mechanisms, rather than relays, because of the continuous high volume of switching required. Unamplified output from the switching reactors is enough to actuate release solenoids in the application mentioned here.

Future Demands

As is the case with most new techniques, the introduction of automatically-controlled handling and storage facilities will be confined initially to particularly intricate or large-scale operations in industries that can afford these techniques.

With advancing technology it is apparent that it is economically feasible and desirable to extend these applications to operations such as mail order houses, postal sorting, high-volume warehousing, and many others for which automatic methods would not have been considered possible even twenty years ago.

Canadian Developments

"It is increasingly clear that we must develop new treatment processes —methods yet unknown and unconceived—which will remove much more of the contaminants from water and wastes than we are able to do by present methods. Because these waste waters are going to become the entire flow of many of our streams as they move along from city to city, science must unravel the mysteries which science itself has created so that our modern urban dwellers—now more than ten million—who must rely on surface water may drink with safety the same water which serves their other needs."[1]

The opening of the St. Lawrence Seaway is one of the new factors in the deteriorating state of Canadian waters and the increasing concern on the part of scientists and legislators. Ontario's urban centres adjacent to the Great Lakes and St. Lawrence Seaway are likely to feel the effects of raw sewage being dumped into the river by lake-going boats. Oil pollution is another problem they present. Ever-increasing metropoli on East and West coasts create a new demand for sewage and industrial waste treatment systems.

The report issued recently by the Montreal Board of Trade concerning water pollution around the Island of Montreal reveals the critical nature of the situation. The Ottawa River and Lake St. Louis are heavily polluted, the former receiving the raw sewage of Ottawa, Hull and Hawkesbury before it enters Quebec. Lake St. Louis, then, is the receptacle for all this sewage as well as the enormous bulk from Montreal lakeshore communities. Two pulp mills along the Ottawa River, in Quebec, also pour their refuse eventually into Lake St. Louis. Although a comprehensive report on the Ottawa River situation was prepared in 1954, a five-man committee was appointed in 1955 to study the extent of water pollution in the Province of Quebec, and legislation was passed in 1955 to assist smaller Quebec communities with construction of sewage and water works, much remains to be done in the Province. The necessity of interprovincial and Federal agreement has been cited as the reason for delay. However, since a sewage treatment plant is planned for Ottawa with a collector sewer to deliver all sewage from below the Chaudière Falls, and since the Ontario Water Resources Commission expects to deal with the Hawkesbury situation shortly, the Montreal water pollution problems lies within the jurisdiction of the Province of Quebec.

The Montreal Board of Trade in its report to the Provincial Government suggests the formation of a commission with wide powers to preserve and control the water resources of the Province: to conduct laboratory research, survey watersheds and lake basins; to construct water supply and sewage treatment plants; to enter into agreements with municipalities or corporations to construct water supply and sewage treatment plants; to raise funds necessary for such construction on the credit of the province; to compel necessary construction and proper maintenance of sewage treatment plants; to prohibit the discharge of harmful material into provincial waters; and to penalize offending parties.

No comprehensive legislation against water pollution exists in Canada. A section of the Criminal Code deals with nuisances; the Shipping Act attempts in part to deal with pollution of navigable waters; the Migratory Birds Convention Act and the Fisheries Act legislate to a degree to protect wild life from the effects of pollution. A number of provinces have anti-water pollution legislation and have formed commissions to study the problems. In Ontario the Commission has especially broad powers of finance, research, construction, and control.

Not long ago Ontario's Prime Minister, Leslie M. Frost, stated that it would take \$2.5 billion over an estimated twenty years to clean up the province's polluted waters. The five-year-old Ontario Water Resources Commission, under the direction of Dr. A. E. Berry, general manager and chief engineer, has made an important start.

During 1959, 19 new joint OWRC-municipal projects were completed and opened, including 12 water works systems and seven sewage works. In the last two years the Commission has undertaken projects to a total value of more than \$21 million. Under construction through OWRC-municipal agreement are another \$20 million worth of sewage disposal and water works projects. The Commission's work is being felt increasingly as new sewage treatment plants at Port Arthur, Brantford, Kitchener, Brampton, Trenton and Huntsville begin to lessen the pollution of receiving waters.

Alberta studies of water pollution were started in the summer of 1950 by the Department of Public Health. At that time municipal sewage was the major source of the pollutants and the

The Atomized Suspension Technique unit, for secondary treatment of sewage, now in operation at Beaconsfield, Que.

1. Gordon E. McCallum, Chief, Division of Water Supply and Pollution Control, U.S. Public Health Service.

Provincial authorities asked Calgary, Edmonton and Lethbridge to expand their sewage treatment facilities in order to give primary treatment to all sewage. In 1953-54 a study was made of a strange odour from the North Saskatchewan River. Extensive study of industrial wastes in the Edmonton area led to control of the situation, however the exact chemical substance responsible for the odour was not determined. The main problem in Alberta is still to maintain sufficient water quality between December and April when the rivers are covered with ice, preventing replenishment of dissolved oxygen supplies and dilution of waste effluents to a safe level.

Since 1955, the treatment facilities provided for new municipal treatment systems in Saskatchewan have been sewage stabilization ponds or lagoons. In the past five years 43 such systems have been constructed, in a few cases replacing conventional systems. Twenty-one conventional systems — activated sludge, standard, high-rate filters, and even an Imhoff tank alone — are in operation.

Canadian sanitary engineers are much concerned in finding new methods of treatment for municipal and industrial wastes. The various provincial commissions have extensive research facilities and various branches of the Professional Institute of Public Service, such as the Department of Fisheries, are making water pollution studies.

In 1953, Dr. William H. Gauvin, Head of the Chemical Engineering Division of the Pulp and Paper Research Institute of Canada in Montreal, while doing research on recovery of chemicals and heat from the spent liquors of sulphite pulpmills, developed the Atomized Suspension Technique for the secondary treatment of sewage. The unit which he developed, the first example of which is now in operation at Beaconsfield, Quebec, is an empty tower whose walls are kept at a temperature of 1000-1400° F. Through an atomizing nozzle at the top of the tower 10-12% sludge is introduced into the heated reactor where a series of physical or chemical transformations take place. When the droplets reach their terminal velocity in the reactor they are repelled from the wall both by the larger thermal gradient next to the wall and by the violence of their own evaporation on the side nearest the wall. This repulsion prevents scaling and corrosion of the reactor wall.

As the suspension moves down the reactor, the droplets become semi-solid particles and enter a drying zone where the internal moisture of the particles diffuses to their surfaces and is evaporated. At the end of the drying zone, physical separation of the solids has been achieved and in the lower half of the reactor the dry solids are suspended in a flow of superheated stream and incondensible gases. Oxidizing air introduced at this stage turns the solids into inert ash. The resulting ash, separated from the gas, can be used as a soil conditioner or passed to the condenser and the plant outfall.

Although the AST unit is in the early stages of application to sewage treatment problems, there is reason to believe that it represents a significant achievement in secondary treatment, demanding less space, time and supervision than conventional processes. However, this is for disposal of retrievable solids in sewage. What is to be done with the effluent from primary treatment is another question.

Opening of Boundary Dam Power Station

The Saskatchewan Power Corporation's new Boundary Dam Power Station near Estevan was officially commissioned on May 14, 1960, by General A. G. L. McNaughton, Chairman of the Canadian Section of the International Joint Commission. The station is situated on Long Creek, an international waterway and tributary of the Souris River, where there are vast supplies of lignite coal. Construction of the power station began in October, 1956, and the dam was completed in the fall of 1957, while the first 66,000 kw. generating unit went into operation in June, 1959, and the second unit in the spring of 1960.

A major part of Saskatchewan's growing power needs will be provided by Boundary Dam and its sister station, the Queen Elizabeth Power Station at Saskatoon. These two large thermal stations will be supplemented by the system's first hydro power when the Squaw Rapids Hydro Station goes into operation toward the end of 1963.

International News

Around the world the crisis of increasing water pollution is impending. Although the necessity of keeping our waters clean has been apparent for over half a century, only in the last decade have legislators begun to face the problems of new industrial wastes and an ever greater volume of domestic sewage. At the same time chemists and engineers have begun to explore for new methods of treating sewage.

Great Britain, France, Germany, the U.S., and Canada are but a few of the countries which recognize that their present water resources are being exhausted faster than scientists can find a way to revitalize used water supplies. They have passed legislation to prohibit as far as possible the further pollution of rivers and lakes by industry; to encourage research in sanitary engineering; to assist financially with construction of new sewage treatment facilities. The greatest need felt at the present time is for new methods of sewage treatment, methods that can meet the new problems posed by chemically complex industrial wastes, by the ever-increasing bulk of municipal wastes and by the new hazard of radioactive particles.

Dr. L. E. Burney, Surgeon General of the U.S. Department of Health's Public Health Service, has stated that an estimated 7,000 totally new chemicals are put to use every year. Conventional sewage treatment methods, designed to deal with essentially organic substances, have little effect on detergents, plastics and thousands of other synthetics which are being poured into our water supplies. He has also pointed out that while we are now still able to get the amounts of pure water that we require, by 1980 the municipal demand will have doubled and the industrial tripled. Gordon E. McCallum, Chief of the Division of Water Supply and Pollution Control of the U.S. Department of Health, Education, and Welfare has cited these figures — Americans now consume approximately 300 billion gallons daily. By 1980 they will need 600 billion gallons. According to our present knowledge of potential water supplies, taking into account all measures available for the reuse of water, the maximum quantity of water available for consumption in 1980 in the U.S. will be 515 billion gallons, or 85 billion gallons less than is called for.

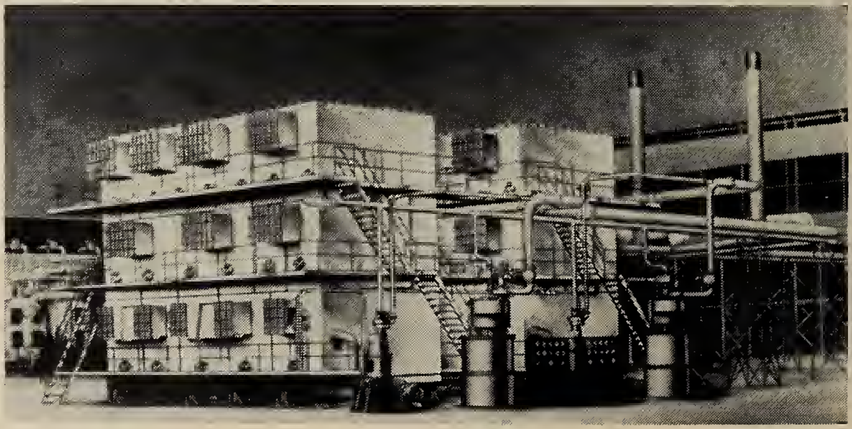
One partial solution to the problem of water shortages appears to be the development of distillation processes for salt water. Sanitary engineers in Glasgow, Scotland have designed a water distillation plant which is operating in various parts of the world, from Aruba in the Netherlands Antilles, to the Channel island of Guernsey. The Aruban plant, the largest distillation works in the world, produces 2,240,000 gallons of pure fresh water from the sea daily. The Guernsey plant is capable of producing half-a-million gallons of drinking water a day. The U.S. has developed a distillation unit, the LTV, or long-tube verticle multiple-effect distillation, which is being used at Harbor Island, North Carolina and Freeport, Texas. Some countries still have sizeable potential water resources as yet untapped, such as Israel where Technion sanitary engineers are investigating the use of the Sea of Galilee waters for drinking purposes.

In July, 1957 the West German government passed laws regulating the use of water. Since then no new water-collecting enterprises have been allowed without government authorization, priority being given to those providing drinking water. Water pollution laws include an enumeration of products which can not be disposed of in water.

Just a year before, in July, the Federal Water Pollution Control Act of 1956 came into being in the U.S. It authorized continued Federal-State-interstate cooperation in programs for controlling water pollution; increased technical assistance to the States, including a broader research program and research fellowships; collection and dissemination of basic data on water quality and treatment; appropriation of $3 million per year for five years for State and interstate grants; Federal grants of $50 million a year for the construction of municipal sewage treatment works; establishment of a Water Pollution Control Advisory Board.

The Robert A. Taft Sanitary Engineering Center has been set up in Cincin-

Sea water distillation plant: The largest installation in the world for converting the sea to fresh water is located at Kuwait in the Persian Gulf. When the new plant is completed, ten and a half million gallons will be distilled a day.



nati, Ohio, as the largest and most modern research facility of its kind in the country. However, extensive research is being carried out in other parts of the country. A study of the beneficial microorganisms in the biological treatment of domestic and industrial wastes has been in progress at the Case Institute of Technology, as a result of two grants from the Public Health Service. Studies of package and subdivision sewage treatment plants have been made recently at the University of Florida Sanitary Engineering Research Laboratory, with the cooperation of the Florida State Board of Health and the U.S. Public Health Service.

A special course in Sanitary Engineering is being offered in Delft, Netherlands, during the academic year 1960-61. The Organization for European Economic Co-operation has endorsed the course for "dealing with a group of technical problems of increasing gravity in densely populated industrial areas" and doing so on an international basis. The belief that water pollution must be dealt with by geographical areas rather than by political units is widespread.

The Chief of the Division of Water Supply and Pollution Control of the U.S. Public Health Service, Gordon E. McCallum, has reported that numerous soluble persistent organics are present in secondary effluents, that is, in water leaving sewage treatment plants, whose effects on human health are undetermined. Viruses of such diseases as infectious hepatitis are known to persist in treated waters, making it clear that ultra-microscopic particles are much more difficult to remove or destroy than bacteria. Soluble chemicals are not appreciably removed from treated water either. Both Mr. McCallum and the Surgeon General, Dr. Burney, have stated that the challenge in combating water pollution is micro-chemical rather than microbiological as it has been traditionally thought.

Some recent developments have been made in treating industrial wastes. A new treatment plant has been installed in a British steelworks which converts the toxic constituents of the effluent into harmless substances by means of bacteriological oxidation. The system involves the isolation of certain bacteria found in well manured soil. These strains are encouraged to multiply and, when properly conditioned, are placed in tanks through which the effluent is pumped. The bacteria absorb the poisonous phenol, using it as a carbon and energy source for reproducing themselves, and thus the process is continuous.

The Swedes have found a method of purifying polluted water by electroshock. Though the process is still in the very early stages of development, experiments have shown that electroshock will kill germs, make solid particles settle at the bottom, and cause certain components of the polluted water to coagulate.

The Great Lakes States and Provinces have similar problems to meet in the water pollution question. They have jointly objected to raw sewage being dumped from lake-going ships using the St. Lawrence Seaway. They coordinately oppose the proposed drilling in Lake Huron. For these reasons they have formed a Canadian-American anti-water pollution committee, and the affected States and Provinces are working with the International Joint Commission on solutions.

An outstanding example of regional cooperation on water pollution problems is the 12-year-old Ohio River Valley Water Sanitation Commission composed of representatives from Illinois, Indiana, Kentucky, New York, Ohio, Virginia, Pennsylvania and West Virginia. It has begun to accomplish its aims with the recent completion of the Alleghany County Sanitary Authority sewage-purification plant which treats the sewage from Pittsburgh's population of 1,400,000 persons at the head of the Ohio River. The Commission plans to build sewage treatment facilities for the 3,600,000 population of municipalities along the Ohio River. It also aims to control industrial waste pollution; to develop information on radio-activity levels on the Ohio River; to try to reduce mine-acid discharges along the river and to bring to a halt the indiscriminate discharge of salt wastes; to curb oil pollution in the river; to inventory aquatic life resources and to develop a monitor system for the appraisal of water-quality conditions.

WINNIPEG COMMITTEE

for the

74th ANNUAL GENERAL AND PROFESSIONAL MEETING

May 25, 26, 27, 1960

J. R. Rettie	Chairman
C. V. Antenbring	Vice Chairman
W. A. Devereaux	Vice Chairman
W. L. Wardrop	Representative & Chairman Branch Management Committee
G. C. March	Secretary
N. S. Bubbis	Publicity
D. C. Bryden	Budget and Finance
R. E. Chant	Technical Papers
F. G. Denson	Hotel Arrangements
W. A. Devereaux	Registration
C. L. Fisher	Reception and Information
G. Flavell	Ladies
J. MacDonald	Plant Visits & Transportation
G. A. Muir	Communications & Projection
R. Noonan	Muriel's Room & Entertainment
T. Weber	Annual Dinner and Dance

Month to Month

(Above) Mr. John Fox of the Engineers Confederation Commission reports to the Annual General Meeting.

(Above right) The Annual General Meeting in session.

EIC *Annual Meeting Winnipeg, 1960*

The new President, G. M. Dick (right) receives the good wishes of his predecessor, J. J. Hanna.

Mr. Hanna congratulates the Right Hon. C. D. Howe, a 1960 Julian C. Smith Medal winner.

Major-General H. A. Young receives his Julian C. Smith Medal from President Hanna. At right, Mr. C. V. Antenbring.

74th ANNUAL GENERAL MEETING

ANY PERFUNCTORY NOTE of appreciation would be a meagre tribute to the arrangements for the 74th Annual General and Professional Meeting. As a thousand members and friends of The Engineering Institute of Canada assembled in the Manitoba capital, the Keystone Province interlocked an impressive number and variety of journeys. Every province from coast to coast was represented, as were our sister societies in the United States and Great Britain. Max Freedman of the British *Manchester Guardian* came from his post in Washington to speak at the Annual Banquet, at which the Mayor of Auckland, New Zealand, was among the head table guests. All found a warm Western welcome, smooth unobtrusive organization, and a program of events that in its conception and execution drew from many quarters the spontaneous comment that this was the most successful Annual Meeting in many a long year.

The efficient transaction of Institute business and the competent handling of professional discussion were the work of many people in the various committees concerned, but all these activities were gaily laced with social events and the whole gift-wrapped in an attractive package that revealed something quite distinctive in the Winnipeg touch.

The Program

Council met on Tuesday, while in other rooms of the Royal Alexandra Hotel the Committee on Technical Operations, the Committee on Education and the Branch Officers' Conference were also in session.

The Annual General Meeting on Wednesday received news of a signal honour to the Institute in the appointment of one of its past presidents, Dr. J. B. Stirling, as Chancellor of Queen's University. The minutes of the Annual General Meeting will appear in an early issue. Technical papers began on Wednesday, accompanied by a novel aid to punctuality — all technical sessions were opened and closed with the skirl of the bagpipes. On Thursday, a lively panel discussion on the relative merits of the yard and the metre was attended by a very large, yet remarkably quiet and attentive audience.

The Committee on Technical Operations convened on Tuesday, and its various divisions began their deliberations the following day. The Students' Conference opened on Wednesday, and the Professional Development Committee met on Thursday. On that day also the Consulting Engineers held their meeting. The Joint A.S.M.E.-E.I.C. International Council met on Friday, and in the afternoon there were field trips to plants in the Winnipeg area.

At the luncheon on Thursday, President J. J. Hanna presented medals, prizes, and certificates of honorary membership. That evening the Consulting Engineers at their Annual Dinner conferred honorary membership of their Association on Dr. C. J. MacKenzie, a past president of the Institute.

At the Annual Banquet on Friday, retiring President Hanna formally introduced the new President, G. M. Dick. The Honourable E. F. Willis, Lieutenant-Governor, bestowed a colourful Manitoba distinction, the Order of the Buffalo Hunt, upon President Hanna and the fraternal delegate from Great Britain, H. Norman Allen, Vice-President of the Institution of Mechanical Engineers. Alderman Crawford, representing Mayor Juba of Winnipeg, gave certificates of Honorary Citizenship to President Dick, retiring President Hanna, past presidents Finlayson and Grant, Mr. Walker L. Cisler, President of the American Society of Mechanical Engineers, Mr. F. A. Marston, President of the American Society of Civil Engineers, Mr. Max Freedman, and Dr. R. L. Hearn. The same honour was conferred on Major-General H. A. Young.

High Fidelity

One insistent theme echoed throughout the meeting: the future of the Canadian engineer is the future of Canada. Nat Bubbis, the publicity chairman, talking to the press on Tuesday afternoon, drew attention to a film showing in the hotel that evening. It was devoted to the Warsak Project in Pakistan, and Nat commended the subject to the newsmen since not only Canadian engineering brains but also Canadian taxpayers' dollars had gone into this Colombo Plan achievement. He went on to say that the technical papers would be of interest not only in the development of engineering, but also in the development of our country. At the opening luncheon next day, the Annual Meeting Committee chairman, Jim Rettie, noted the titles of technical papers read at the Winnipeg meeting of 1911 and commented: "Those boys were really giving Canada a hand." The speaker at the luncheon was the Honourable C. H. Witney, Manitoba's Minister of Mines and Natural Resources, and he depicted today's engineer as a new frontiersman, doing the job that has to be done; the politician had the important duties of ordering it done and dealing with the side effects which are so important to the livelihood and welfare of the people. Each needed the other, and the engineer was often dependent on those less trained and less skilled. On Friday evening, Max Freedman was to make this same point in appealing for a constant line of creative communication between the elected representative and the hard working expert.

"That is your history all through the years", Alderman Crawford told us that same evening, "that you do the things that the rest of us want done." On Thursday, President Dick had told the new Council that we must put Canada out in front with an efficient program of E.I.C. technical operations if we are to keep this country where it belongs. The importance of this goal was highlighted by Max Freedman's claim that it is the glory of the American and Canadian democracies to have proved that there is no conflict between freedom and abundance. And he went on to deplore the attitude of those who assume our civilization to be beyond the meridian of its growth, when in reality "it is but at the cock-crow and the morning star."

The A.S.M.E.-E.I.C. International Council. Standing, L. to R.: G. T. Page (E.I.C.); P. W. Gooch (E.I.C.); G. C. Southmayd (E.I.C.); J. A. Thomas (E.I.C.); H. G. Conn (E.I.C.). Seated, L. to R.: G. M. Dick (E.I.C.); H. I. Muller (A.S.M.E.); L. C. Sentance (E.I.C.), Chairman; J. J. Hanna (E.I.C.); O. R. Schier II (A.S.M.E.).

President Dick and Retiring President Hanna with Mr. W. L. Cisler, President of the American Society of Mechanical Engineers.

At the Awards Luncheon. L. to R.: Dr. W. P. Dobson; Dr. R. L. Hearn; Mr. J. J. Traill. Drs. Dobson and Hearn received Honorary Memberships. Mr. Traill's paper "Test of Hydraulic Turbines—and Appraisal" was awarded the Robert W. Angus Medal.

(Left) The Opening Luncheon. L. to R.: Mr. C. V. Antenbring, joint Vice-Chairman, Annual Meeting Committee; Mrs. S. Barkwell; Hon. C. H. Witney (speaker); Mr. J. R. Rettie, Chairman, Annual Meeting Committee.

(Below) At the Ladies' Dinner. L. to R.: Mrs. E. P. Fetherstonhaugh; Mrs. J. Finlayson; Mrs. W. A. Vance; Mrs. G. M. Dick; Mrs. K. F. Tupper; Mrs. V. A. McKillop; Mrs. D. M. Stephens.

Two 3rd-year Civil Engineering students at the University of Manitoba kept the technical sessions on time. Doug Chivers is the piper, and his standard bearer, Gord Crabtree.

(More pictures on page 165)

Engineers Confederation Commission

Progress Report to the 1960 Annual Meetings of the Canadian Council of Professional Engineers and The Engineering Institute of Canada

A. GENERAL

1. A short time after its appointment, the Engineers Confederation Commission met in Toronto. The meeting, which had almost full attendance, appointed nine task committees to undertake the major studies required, by the terms of reference assigned the Commission by the Report of the Committees on Confederation, dated March 18, 1959. These committees were appointed on a geographical basis, both to ensure that a broad reflection of opinion from all parts of Canada was obtained, and to keep travel costs to a minimum.

2. The chairmen and terms of reference of these nine committees are:

(a) **Charter—**
Chairman: J. G. Dale.
"To draft a complete charter, using the E.I.C. charter as a basis if possible".

(b) **By-Laws—**
Chairman: H. Gaudefroy.
"To draft all necessary by-laws, assuring that these are consistent with the Charter".

(c) **Administration—**
Chairman: T. Foulkes.
"To spell out the broad lines of how the new national body would be administered".

(d) **Finance—**
Chairman: E. D. Gray-Donald.
"To work out the details of how the new body will be financed, in co-operation with the Committee on Administration".

(e) **Branches—**
Chairman: W. K. Gwyer.
"To determine how the branches would be formed, financed, operated, etc., and their relationship with the national body and the provincial associations".

(f) **Other Societies—**
Chairman: J. Herbert-Smith.
"To survey possible co-operation with, and participation of, other societies, (Canadian, U.S., British, or foreign technical societies and professional engineering bodies) as distinct from the two participating groups".

(g) **Services—**
Chairman: J. B. Mantle.
"To outline the various services to be performed by the new national body".

(h) **Relationship With the Provincial Associations—**
Chairman: J. Hoogstraten.
"To establish the relationship between the new national body and the provincial associations".

(i) **Co-ordinating—**
Chairman: J. H. Fox.
"To co-ordinate the work of the committees and to establish the details of implementation of the decisions of the Commission".

3. The secretariat of the Commission is shared by Leo M. Nadeau, Executive Secretary of the C.C.P.E. and Garnet T. Page, General Secretary of E.I.C.

4. Proper arrangements have been established for the banking, accounting and audit procedures for the operating funds that have been entrusted to the Commission by the C.C.P.E. and the E.I.C. on an equal basis.

B. PROGRESS

1. Following the meeting of the Commission in October, 1959, the task committees proceeded vigorously to develop their assigned work. In March, 1960, so much real progress had been made by the committees that a meeting of the Co-ordinating Committee was held, at which encouraging progress reports were received from all committee chairmen, and further instructions and directions were given to the committees.

2. After the Co-ordinating Committee meeting in March, each committee revised and added to its reports, in preparation for the second meeting of the Commission in Toronto on April 23, 1960, which again had almost 100% attendance. As a result of the work completed at this meeting, the following progress report is submitted:

(a) It is apparent to the Commission that Confederation of the C.C.P.E. and the E.I.C. is possible within the requirements which are set forth in the terms of reference of the joint report.

(b) In more detail:

(i) A final draft of the charter, making use of the present E.I.C. charter, is now complete except for a few minor details. Naturally, the E.I.C. charter has had to be amended substantially to meet the needs of the new national body, and to make specific provisions so that the decisions of the national body are not binding upon the provincial associations if such decisions in any manner concern the application of the provincial engineering acts or other provincial acts. Provision is made for the location of headquarters to be at the discretion of Council. A complete final draft charter should be available at an early date, and no difficulties are anticipated.

(ii) Excellent progress is being made in the preparation of draft by-laws to govern the administration and management of the national body. These draft by-laws are consistent with the provisions of the draft charter. The By-Laws incorporate provisions for the establishment of a national Council, the administration, services, classes of membership, and relationships with other associations and societies that are being planned.

(iii) A plan is being prepared for the administration of the proposed national body, to enable it to render enlarged professional and technical services to the membership. This plan includes methods of organizing the membership so that services may be of maximum value to the largest number of members.

(iv) The amount of the assessment per member is receiving careful attention from the point of view of essential services to be rendered. Every effort is being made to provide these services at the minimum reasonable cost, bearing in mind present overall economic conditions.

(v) Detailed proposals for enlarged branch activity and for branch participation in national activities are being prepared. These proposals allow for the merging of existing association and E.I.C. branches where they exist in the same community, and provide a mechanism for the formation of new branches where requested. Careful consideration is being given to the problem of adequate communications between branches and the national body as well as between branches and the provincial associations. An underlying principle of the Commission's planning with regard to branches is that membership in a branch shall be on a voluntary basis. Provision is being made to allow the formation of student sections of branches in areas where there are universities and where needed.

(vi) Plans have been developed for a programme which will permit the development of national technical divisions and local technical divisions of members of the national body, and for full co-operation with other technical and professional societies, with a view to augmenting the services of the national body to the members by these relationships.

Proposals are also being prepared to allow the development of functional sections at the local, provincial and national levels to permit the grouping of members with common functional interests at any or all levels if and when desirable.

(vii) Generally speaking, the plans for services to be rendered by the national body are a combination, and in many cases an amplification or broadening, of the services now being provided by the C.C.P.E. and the E.I.C. in the interests and for the welfare of the members. Special attention is being given to the provision of a national journal and an overall publication programme.

C. *COMMISSION FINANCES*

The cost of operating the Commission to date has been approximately $10,000.00. It is impossible to estimate the vast expenditure of time, effort, and enthusiasm that has been given freely by each and every member of the Commission, but it is certainly not at all comparable to or represented by this small expenditure of money.

D. *ANTICIPATED TIMING*

It is anticipated that, with the progress made to date and the instructions that have been issued for further work, it will be possible to call two meetings of the Co-ordinating Committee in the Fall of 1960 and a full meeting of the Commission in December. Arising from these meetings, it is hoped that a well developed report, in the final stages of preparation, will be available in January, 1961, for presentation to the C.C.P.E. and the E.I.C.

E. *EXTENSION OF APPOINTMENT OF THE COMMISSION*

It is requested that in order to complete the Commission Programme that the members of the Commission, whose first year of appointment expires in October, 1960, be re-appointed for a second year by the C.C.P.E. and E.I.C. consistent with provision of the joint report.

F. *PUBLICITY*

It is requested that the C.C.P.E. and the E.I.C. re-affirm and continue the existing policy that the only information which these bodies publish regarding the work of the Commission be that which is provided officially by the Commission for that purpose.

It is anticipated that, as the work of the Commission progresses, more complete and detailed information will be made available.

Respectfully submitted,
John H. Fox, Chairman
L. Roy, Vice-Chairman

May 5, 1960.

Officers of the Branches

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Chairman, G. C. L. McEnery, 65 Bridge St., Sackville, N.B.
Secretary-Treasurer, G. B. Turnbull, 47½ Havelock St., Amherst, N.S.

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Secretary, L. Tellier, Manoir Comeau, Baie Comeau, Que.

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Secretary-Treasurer, D. A. Law, 54 Montgomery Blvd., Belleville, Ont., Tel. WO. 2-4511.

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Secretary-Treasurer, P. J. Dallien, 921 Carthage Ave., Bathurst, N.B.

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Secretary-Treasurer, L. E. Fischer, c/o Iron Ore Co. of Canada, Dock Terminal, Seven Islands, Que.

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Secretary, J. N. Prichard, 2234 McQuaig St., Ottawa 1, Ont., Bus. Tel. CE. 6-7531, LOC. 226.

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Chairman, R. M. Allemang, 714 Walkerfield Ave., Peterborough, Ont., Bus. Tel. RI. 2-7711, Ext. 361.

Secretary-Treasurer, Peter Tuck, c/o Canadian General Electric Co., 107 Park St. North, Peterborough, Ont., Tel. RI. 2-7711, Ext. 471.

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Secretary-Treasurer, D. A. Runciman, 49 Chapel St., Cobourg, Ont.

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Secretary-Treasurer, E. S. Chandler, 242 North River Rd., R.R.2, Charlottetown, P.E.I.

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Chairman, B. I. Burgess, c/o Canadian General Electric Co. Ltd. Industrial Centre 5, Quebec, Que., Tel. MU. 3-3431.

Secretary-Treasurer, Marc Bergeron, c/o Concrete Repairs & Waterproofing Co., 128 Blvd. Ste. Anne, Quebec, Que.

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Secretary-Treasurer, J. R. Eason, 533 Normandie St., Arvida, Que.

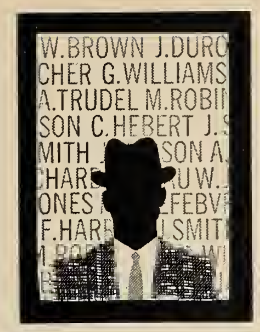
SAINT JOHN

Chairman, J. B. Eldridge, 569 Sand Cove Rd., Lancaster, N.B.

Secretary-Treasurer, J. P. Mooney, 50 Princess St., Saint John, N.B.

(Continued on page 124)

Personals



R. A. Campbell, M.E.I.C. has been appointed director of engineering for Eastbourne Construction Consultants Ltd., Toronto.

H. G. Hilton, M.E.I.C. (Case School of Applied Science '10), Chairman of the Board and Chief Executive Officer of the Steel Company of Canada, retired from active service April 1, after 41 years with the company. Mr. Hilton will continue as Chairman of the Board of Directors of the company.

John L. Cavanagh, M.E.I.C. (N.S.T.C. '11), President of the Malagash Salt Company Limited, and **Geoffrey A. Gaherty,** M.E.I.C. (Dalhousie '09), President of the Montreal Engineering Company Limited, were presented with Honorary Doctor of Engineering degrees at N.S.T.C.'s annual convocation, May 11.

L. W. Pillar, M.E.I.C.

H. W. Tate, M.E.I.C.

H W. Tate, M.E.I.C. (Toronto '10) and L. W. Pillar, M.E.I.C. (Kings College '25) have joined Ewbank & Partners (Canada) Limited, consulting engineers, Toronto, as Principals of the company.

P. W. Voisey, M.E.I.C. has taken a position with the Research Branch at the Central Experimental Farm, Ottawa.

Arthur Piche, M.E.I.C. (Ecole Polytechnique '30) has been elected President of the Corporation of Professional Engineers of Quebec. He is Engineer of Public Works for Quebec City and professor of municipal engineering at Laval University.

Andrew H. Wilson, M.E.I.C. (Glasgow '49) has been appointed Scientific Administrative Officer of the Physics Division of Atomic Energy of Canada Ltd.

G. Y. Sebastyan, M.E.I.C. (Michigan '53) is Research and Evaluation Engineer with the General Engineering Design Section, Airport Development, Construction Branch, Department of Transport, following a recent appointment.

R. F. Swain, M.E.I.C. has retired from the Royal Canadian Navy and is now serving as Superintendent of Ship Construction and Maintenance, Canadian Hydrographic Services, Department of Mines and Technical Resources, Ottawa.

G. Ross Dance, M.E.I.C. (Toronto '34) has been appointed Manager, Nylon Intermediates, at the Maitland Works of Du-Pont of Canada Limited.

Terence J. Farrell, M.E.I.C. (N.S.T.C. '46) has been appointed manager of Plate and Mechanical Sales, of Canadian Vickers, with headquarters in Montreal.

K. R. Meyer, M.E.I.C. (London '37) has rejoined Stadler, Hurter & Company as Project Manager. Prior to this he was Assistant Chief Engineer at the E. B. Eddy Company, Hull, Quebec.

F. C. Ansley, M.E.I.C. (Queen's '37) President and General Manager of Con-Eng Contractors Ltd., has been elected President of the Ontario General Contractors Association.

Marcel Carrier, JR.E.I.C. (Laval '47) has been appointed chief engineer at the Lower St. Lawrence Power Company, **Fernand Roy,** JR.E.I.C. (Laval '50) is the company's new system superintendent, while **Gerard Fournier,** M.E.I.C. (Laval '56) has been appointed distribution engineer.

Robert T. Crawford, M.E.I.C. (Manitoba '48) has been appointed Southern Alberta District Manager of the Canadian Ice Machine Company Ltd., with headquarters in Calgary.

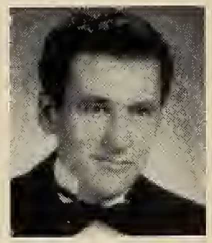
George F. S. Davis, M.E.I.C. (Alberta '49) has accepted the position of Co-ordination Engineer with Rudberg Bros. Inc., Construction Project Managers for the new 34-storey C-I-L House. Mr. Davis was formerly Eastern Division Engineer with the construction subsidiary of the Hudson's Bay Company.

G. R. McMeekin, M.E.I.C. (Alberta '41) has been appointed Special Assistant, Administration of The Consolidated Mining and Smelting Company of Canada Ltd., Trail, B.C.

Jan A. Vandergiessen, M.E.I.C., has been named Alberta Representative of Read Jones Christoffersen, consulting engineers, Vancouver and Edmonton, and will be in charge of the Edmonton office.

Arthur E. Lea, M.E.I.C. (London '46) has recently joined Frederick Parker (Canada) Ltd. as Western District Representative and will reside in Edmonton. He has previously been with the Department of National Defence on development projects for the Canadian Army.

A. E. Lea, M.E.I.C.



R. R. Duquette, M.E.I.C.

R. R. Duquette, M.E.I.C. (Ecole Polytechnique '32) has been elected President of the Association of Consulting Engineers of Canada. He is a member of the consulting engineering firm of McDougall & Friedman, Montreal.

J. E. Miller, JR.E.I.C. (Alberta '52) has been elected to the Board of Directors of Catalytic Construction of Canada Limited. He is General Field Superintendent of all the company's operations.

G. E. Plant, M.E.I.C. (U.B.C. '50) has been named Manager of the Paper Machinery Division of the Dominion Engineering Works Limited.

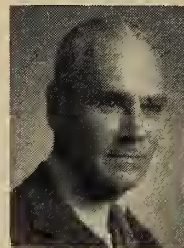
Norman F. Stewart, M.E.I.C. (N.S.T.C. '51) has been appointed City Engineer of Charlottetown, P.E.I. He leaves his post as engineer with the County Construction Company.

J. Douglas Kline, M.E.I.C. (N.S.T.C. '40) was recently elected Chairman of the Canadian Section of the American Water Works Association. He is General Manager of the Halifax Public Service Commission.

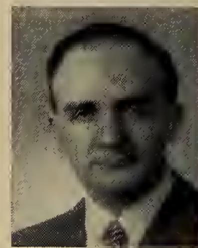
George Lawrence Fox, S.E.I.C. (McGill '59) has taken up the position of Sales Assistant in the Apparatus Division of Canadian Westinghouse Company.

Tony W. Cliteur, JR.E.I.C., formerly employed by the City of Regina, has been appointed Town Engineer for the Town of Kindersley, Saskatchewan.

H. G. Welsford, M.E.I.C. has been appointed Chairman of the Board of Dominion Engineering Works Ltd., Montreal.



H. G. Welsford, M.E.I.C.



W. C. Viner, M.E.I.C.

William C. Viner, M.E.I.C. (McGill '41) is now Chief Engineer at the Donald Inspection Company Ltd., Montreal.

John M. Hubicki, JR.E.I.C. (Toronto '56) is the new County Engineer and Roads Superintendent of the County of Peterborough, Ontario.

Robert T. Bailey, M.E.I.C. (Queen's '48), formerly City Engineer of St. Catharine's, Ontario, is now Works Commissioner of Windsor, Ontario.

Winnett Boyd, M.E.I.C. (Toronto '39) has been appointed President of Arthur D. Little of Canada, Limited, in Toronto. Until this time, he has been President of his own firm, Winnett Boyd Limited, and senior partner in his consulting organization, Winnett Boyd Associates.

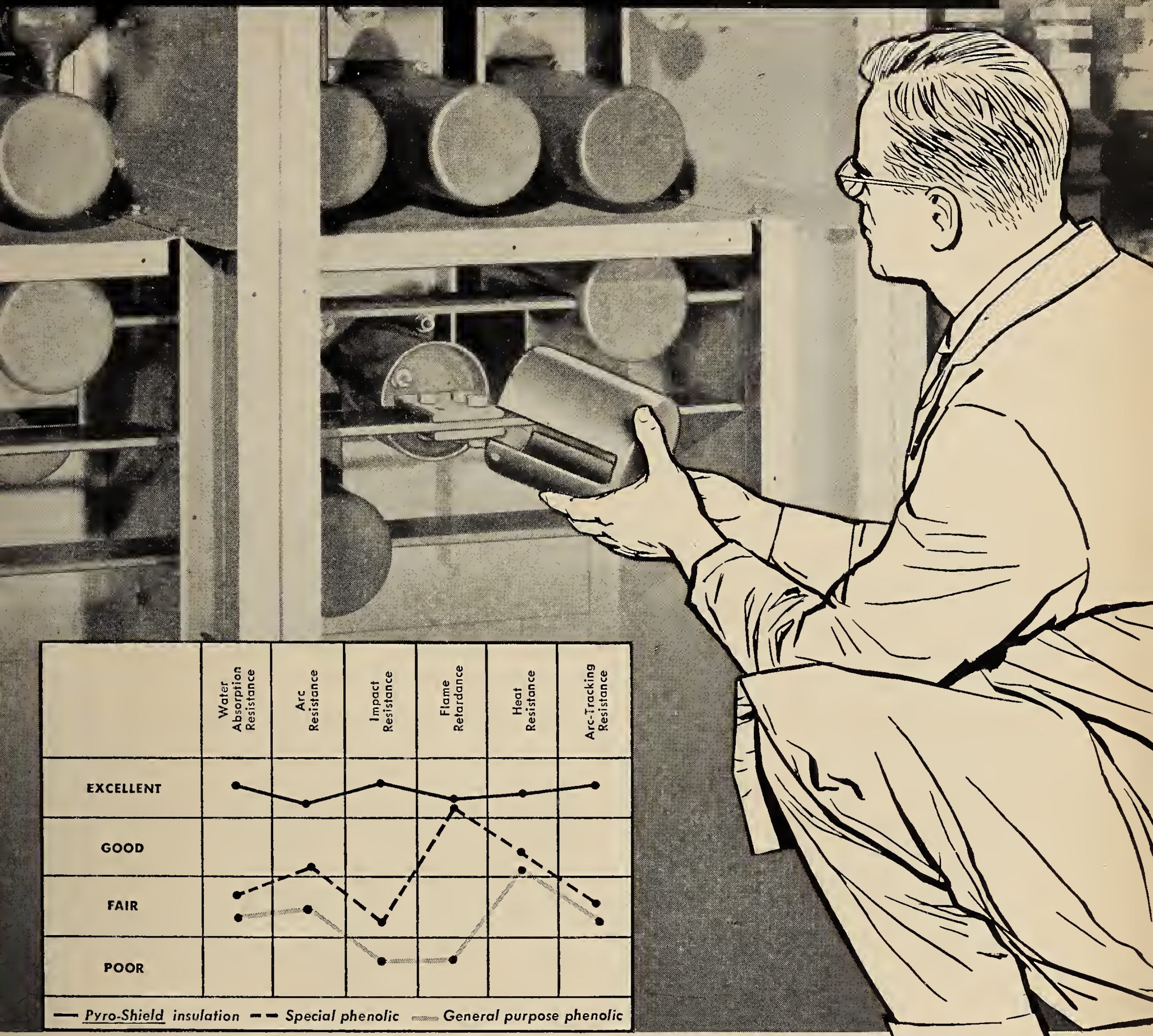
W. Boyd, M.E.I.C.

E. J. M. Knitel, M.E.I.C.

Erich J. M. Knitel, M.E.I.C. (Federal Institute of Technology, Vienna '34) has been appointed Technical Executive Officer in the Montreal Office of the Canadian Overseas Telecommunication Corporation. Mr. Knitel was formerly employed as Staff Engineer with The Shawinigan Water and Power Company.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Allis-Chalmers New 4.16-kv Metal-Clad Switchgear



PROTECTED WITH PYRO-SHIELD INSULATION ALLIS-CHALMERS

New Pyro-Shield Track-Resistant Insulation

Track-resistant *Pyro-Shield* insulation is a polyester glass base material now used in Allis-Chalmers co-ordinated system of switchgear insulation.

One molding connects primary disconnects to bus bars to provide uniform insulation and reduce the number of insulation components.

In addition to being track resistant, *Pyro-Shield* insulation has high impact strength, which eliminates risk of damage from short-circuit stress and assures low moisture absorption.

Other advantages are: high flame retardance; long life — even at high temperatures; resistance to chemical fumes; and bus joint construction that eliminates need for skilled taping techniques.

Get details on this new insulation and other Allis-Chalmers switchgear features, including the low 72-inch silhouette and new *Shelter-Clad* design. Contact your nearby Canadian Allis-Chalmers office, or write Canadian Allis-Chalmers, Switchgear Dept., 55 Burwell Rd., St. Thomas, Ont.

For Progress in Switchgear

Made in Canada

CANADIAN ALLIS-CHALMERS A-C ALLIS CHALMERS

Pyro-Shield and Shelter-Clad are Allis-Chalmers trademarks.

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• OFFICERS OF THE BRANCHES

(Continued from page 114)

SAINT MAURICE VALLEY
Chairman, Wm. A. Pangborn, 3930 Des Plaines, Three Rivers, Que.
Secretary, W. G. Low, 1970 Lajoie St., Three Rivers, Que.

SARNIA
Chairman, A. W. Wirth, 611 Cathcart Blvd., Sarnia, Ont., Tel. ED. 7-8221, Loc. 608.
Secretary, R. W. Hodgson, 885 Kemsley Drive, Sarnia, Ont., Tel. ED. 7-8221, Loc. 656.

SASKATCHEWAN
Chairman, L. T. Holmes, 3057 Retallack Street, Regina, Sask., Tel. Lakeside 3-7560.
Secretary-Treasurer, R. Bing-Wo, 2043 Cameron Street, Regina, Sask.

SAULT STE MARIE
Chairman, N. A. Paolini, c/o Dominion Bridge Co. Ltd., P.O. Box 520, Sault Ste. Marie, Ont.
Secretary-Treasurer, M. R. Wright, c/o Dominion Bridge Co. Ltd., P.O. Box 520, Sault Ste. Marie, Ont., Tel. AL. 6-5611.

SUDBURY
Chairman, E. M. Powell, 164 Elm St. East, Sudbury, Ont.
Secretary-Treasurer, C. L. MacMillan, 1237 Woodbine Ave., Sudbury, Ont.

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Chairman, A. M. Toye, 102 Bideford St., Downsview, Ont., Tel. CH. 4-2571, Loc. 492.
Secretary-Treasurer, C. L. Thompson, c/o Honeywell Controls Ltd., Vanderhoof Ave., Leaside, Toronto, Ont., Tel. HU. 9-2151.

VANCOUVER
Chairman, C. P. Jones, 4130 Capilano Rd., North Vancouver, B.C.
Secretary-Treasurer, R. Clough, 1232 Dogwood Crescent, North Vancouver, B.C.

VANCOUVER ISLAND
Chairman, L. C. Johnson, 3051 Larkdowne Rd., Victoria, B.C.
Secretary-Treasurer, R. W. Lockie, 314 Cadillac Avenue, Victoria, B.C.

WINNIPEG
Chairman, W. L. Wardrop, 456 Notre Dame Ave., Winnipeg, Man.
Secretary-Treasurer, W. N. Isberg, 39 Turner Ave., Winnipeg 12, Man.

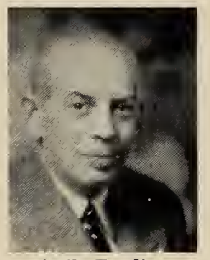
YUKON
Chairman, J. H. Reeves, c/o Northwest Hwy. Maintenance Est., Whitehorse, Yukon.
Secretary, J. P. MacGowan, c/o Northwest Hwy. Maintenance Est., Whitehorse, Yukon.

ONTARIO DIVISION
Chairman, H. R. Sills, 542 Gilmour St., Peterborough, Ont.
Secretary, John G. Hall, 92 Heddington Ave., Toronto, Ont.

Obituaries

Arthur Balfour Darling, M.E.I.C., President of Darling Brothers Limited, Montreal, died on April 25, 1960.

Born in Montreal in 1902, Mr. Darling graduated from McGill University in 1924 and began his career with the Darling Brothers Company as an engineer. He held various positions with the company and was elected to its presidency in 1956.



A. B. Darling
M.E.I.C.

Mr. Darling was a member of the Corporation of Professional Engineers of Quebec.

He was also a governor of the Montreal General Hospital and a past president and honorary president of the Whitlock Golf Club.

Gilles G. Fortin, S.E.I.C., died suddenly on January 13, 1960, at the age of 22. He had been employed by the Bureau of Patents and Copyrights in Ottawa.

A native of Adamsville, Quebec, Gilles studied at the College Sacre-Coeur in Granby and in May of last year received his degree in mechanical engineering from the University of Sherbrooke. During the summer, for the past two years, he worked for the City of Sherbrooke. He was a member of the Signals Corps at Kingston, Ontario.

Lee Morgan Jones, M.E.I.C., of Islington, Ontario, died on August 21, 1959.

Born in Wales, Mr. Jones came to Canada in 1896 and joined the Canadian Pacific Railway Company in Winnipeg as a draughtsman in 1899. Subsequently he went to work with the Winnipeg Electric Railway Company, directing track-laying and construction of car barns and sub-stations. In 1906 he was appointed Assistant City Engineer of Port Arthur, Ontario, and in 1911 became City Engineer.

Mr. Jones joined the Warren Bituminous Paving Company in 1920. He was elected to the board of directors in 1923 and made Chief Engineer and Secretary of the company. He retired in 1947.

A member of the American Society of Civil Engineers and also the Association of Professional Engineers of Ontario. Mr. Jones was made a Life Member of the Institute in 1947.

He was a member of the Rotary Club for more than twenty-five years and was particularly active on the Crippled Children's Committee of the Toronto club. He was also a member of Deer Park United Church and served as a member of the Board of Managers.

Camille C. S. LeClair, M.E.I.C., formerly of Toronto, died on December 26, 1959, in Devon, England.

After wide experience in senior engineering positions in England and Japan, Mr. LeClair came to Canada and set up a consulting practice and an engineering research organization in Toronto which he incorporated into LeClair Engineering Company in 1954. He later joined Peacock Brothers Limited in Toronto, as Chief Engineer.

In 1944 Mr. LeClair was appointed Staff Officer of the Royal Engineers at First Canadian Army Headquarters. He became first Assistant Director, then Director in the Directorate of Works and Accommodation at headquarters after the war. In 1950 he was appointed command engineer of the Central Command.

Mr. LeClair's original contributions to engineering brought him over one hundred and fifty patents during the course of his career. He was most recently working on the design of Arctic vehicles.

Mr. LeClair was a member of the Institution of Mechanical Engineers, U.K.

Kenneth Hadley Tremain, M.E.I.C., died in Minneapolis, Minnesota, on May 24, 1960, at the age of 55.

A native of Windsor, Nova Scotia, Mr. Tremain received his education from King's College, Windsor; Ashbury College, Ottawa; Royal Military College, Kingston; and McGill University from which he graduated in 1929.

In 1940 Mr. Tremain went overseas, after serving with the 7th Medium Battery of the Royal Canadian Artillery for a year. Upon graduating from the First Canadian Junior Staff College in England, he returned to Canada to assume a staff appointment with the Fourth Canadian (Armoured) Division. In 1945 Mr. Tremain retired from the army with the rank of colonel and was awarded the Order of the British Empire in recognition of his war service.

After the war he joined National Breweries, as a representative of the company in New York. More recently Mr. Tremain acted as Montreal representative of Canadian Zurn Industries.

Lionel Mortimer Stein, S.E.I.C., a graduate in mechanical engineering from McGill University, 1959, died in Boston on April 27, 1960. He was 22 years old.

Frederick Holroyd Paulson, M.E.I.C., of Charles A. Maguire & Associates, Providence, Rhode Island, died in September, 1959.

Charles St. Barbe Kindersley, M.E.I.C., of Calgary, died on February 12, 1960.

Word has reached the Institute of the death of **Digby Wyatt,** M.E.I.C., formerly of J. Brockhouse & Company (Canada), Toronto.

Fred A. Annett, AFFIL. E.I.C., of Flushing, New York, died on October 16, 1959.

Other Societies

1960 Nuclear Congress Papers

The proceedings of the 1960 Nuclear Congress held in New York City in early April are now being distributed. They may be ordered from: The 1960 Nuclear Congress, 29 West 39th Street, New York 18, N.Y.

The Nuclear Congress produced new information in a variety of subject areas related to the application of nuclear energy for mankind's benefit. The Engineering Institute of Canada was one of 28 engineering and scientific organizations supporting the Congress.

Engineering Index

A 1600 page guide to the current technological literature of the world for the year 1959 will come off the presses this month in the form of *The Engineering Index*. The information is indexed under two hundred and forty-nine divisions of engineering. A complete catalogue outlining the coverage of each of these divisions is available upon request.

The Engineering Index, a non-profit organization, hires a staff of qualified editors who review articles concerning the application of engineering methods and concepts in every phase of the economy.

University of Hong Kong Congress

Among the various sessions planned to celebrate the University of Hong Kong's Golden Jubilee from September 11-16, 1961, is a symposium on The Design of High Buildings. It is intended to cover recent theoretical and practical developments, both on the architectural and engineering side, in the planning, design and construction of multi-storey buildings. Those who wish to offer papers are requested to send a synopsis to the General Secretary by December, 1960.

The Institution of Civil Engineers (UK) Award

The Kelvin Gold Medal, 1959 was awarded to Professor Sir Geoffrey Ingram Taylor on February 16, 1960, at the Institution of Civil Engineers, London. Sir Geoffrey's remarkable studies of turbulence, as well as his inestimable scientific contributions during the war years, were cited on this occasion.

ASME Elmer A. Sperry Award

Frederick D. Braddon, inventor of the gyro-compass that guided the atomic submarines Nautilus and Skate under the ice cap of the North Pole, was honoured in Philadelphia on May 4 by four American engineering societies for "an outstanding contribution to the field of transportation".

Canadian Institute of Steel Meeting

More than 200 structural steel and plate fabricators and guests assembled at Montebello, Quebec to elect new officers and exchange technical information on May 13. Among the speakers were Tom Stevenson of the British Iron and Steel Federation, London, England, who discussed Steel Development in the United Kingdom and Europe; G. Hardenberg, Vancouver, co-designer, who spoke on the new Port Mann Orthotropic Bridge; and David Holbrook, President, Algoma Steel Corporation, on Increasing Canada's Steel Production.

AIC Publishes Bibliography

"Evaluation of Strength Tests of Concrete" is the title of bibliography no. 2 published by the American Concrete Institute. This new bibliography lists and annotates selected articles appearing in available technical publications issued from 1924 to 1958 on the subject of compression tests on concrete.

M.I.T. Summer Course

In response to widespread interest in the theory and operation of nonradiative

The Associations and Corporation

At the annual meeting of the Canadian Council of Professional Engineers held in Saint John, New Brunswick, May 11-13, 1960, the following were elected officers for the ensuing year: president, J. G. Dale, M.E.I.C., Edmonton; vice-president, W. L. Wardrop, M.E.I.C., Winnipeg; and member of the executive, D. S. Simmons, M.E.I.C., Toronto.

J. Graham Dale, M.E.I.C., newly elected President of the Canadian Council of Professional Engineers, was born in Cranbrook, B.C. and educated at the University of Alberta, where he graduated in 1934 with a B.Sc. in electrical engineering.

Mr. Dale began his career in engineering with Northwestern Utilities Limited in Edmonton as a serviceman. In 1947 he was made Chief Salesman and Utilization Engineer; in 1952, Manager of Sales and Service; and in 1957, Manager of Customer Service and Utilization.

During World War II Mr. Dale was a member of the reserve forces, serving with No. 1 (R) Armoured Divisional Ordnance Workshop, R.C.O.C. From 1947-49 he was a Captain in the R.C.E.M.E. reserve forces.

He has been a Member of the Institute since 1940; a Member of the Association of Professional Engineers of Alberta since 1941, serving as Registrar, 1943-47, and Councillor, 1948-52, Association's Representative on the Engineering Faculty Council, University of Alberta, 1952-59, Vice-president, 1955, President, 1956, Representative of Alberta on Canadian Council, 1958 to present, and Representative of Alberta on the Engineers Confederation Commission, 1959 to date.

self-contained guidance systems, the Massachusetts Institute of Technology will present a special summer program in Inertial Guidance — Terrestrial and Interplanetary, from July 5-15, 1960. Lecturing will be done by members of the M.I.T. Department of Aeronautics and Astronautics. Tuition is $325, due and payable upon notification of admission. Academic credit is not offered.

Course in Sanitary Engineering, Delft

The Technological University at Delft and the Netherlands Universities Foundation for International Co-operation will offer a course in Sanitary Engineering from October 19, 1960 to September 14, 1961. The World Health Organization and the Organization for European Economic Co-operation will also assist in giving the course. It is aimed at providing civil engineers with special training in sanitary engineering to enable them to take part in the struggle with water pollution in densely populated and highly industrialized areas.

For further particulars, write to NUFFIC, 27 Molenstraat, The Hague, The Netherlands.

Fluid Mechanics and Solid Mechanics Conference

Plans are being made for the Seventh Midwestern Conference on Fluid Mechanics and Solid Mechanics to be held at Michigan State University, East Lansing, Michigan, September 6-8, 1961. Authors who wish to present papers should send in their abstracts by January 1, 1961. For further information, address inquiries to: Professor J. E. Lay, Mechanical Engineering Department, Michigan State University, East Lansing, Mich.

Coming Events:

Dechema — Jahrestagung, Frankfurt (Main)—June 14-16

International Congress of Chemical Engineering, Mexico City—June 19-22

American Society for Testing Materials Annual Meeting, Atlantic City, N.J. —June 26 to July 1

Institute of the Aeronautical Sciences Meeting, Los Angeles, Calif.—June 28 to July 1

Conference on Civil Engineering Education, University of Michigan (Ann Arbor)—July 6-8

Seminar on Low-cost Automation, Pennsylvania State University—July 7-8

Instrument Society of America Instrument-Automation Conference, New York City—September 26-30

Canadian National Material Handling Show and Conference, Montreal—September 26-30

Prestressed Concrete 6th Annual Convention, New York City—September 27-30

Canadian Chemical Engineering Conference, Quebec City—November 6-9

National Die Casting Exposition and Congress, Detroit, Mich.—November 8-11

International Plastics Exhibition and Convention, London—June 21 to July 1, 1961.

News of the Branches

Belleville

Wilburt L. Caniff, JR.E.I.C.,
Correspondent

COMMUNIST BRAINWASHING METHODS during the Korean War were heard on a tape recording at the Annual Meeting, April 11.

Elected officers for 1960-61 are: chairman, H. T. Floyd; vice-chairman, F. E. Moore; members of the executive, for two years, H. S. V. Gibbon, A. G. Tooth, and M. McQueen; and executive member for one year, R. E. Churcher.

Engineers' meeting with secondary school and technical students of Rimouski: (left to right) Andre Leroux; Patrice Dionne; Marcel Carrier; Leon Dancose, chairman of the Lower St. Lawrence Branch; Gerard Fournier, secretary-treasurer; Jean Menard, councillor; Carol Moison; Victor Banvelle; Paul Begin; George A. Santerre, regional representative of the C.P.E.Q.

Cape Breton

Lloyd R. Boutilier, M.E.I.C.
Correspondent

THE ART OF FORGING was discussed by Mr. Richard Jamieson, Chief Metallurgist, Trenton Steel Works, Trenton, N.J., at the March 28th Meeting. He described the processes of edging fullering, bending, and blocking impressions, and explained that if dies were available many more castings could be made. Also under discussion were: heat treatment of forgings; specifications in testing; test pieces; and inspection by the periscope or boroscope method.

Six gentlemen associated with the steel industry in Yugoslavia were the special guests at this meeting. Accompanied by interpreters and a U.S. government representative, the men were on tour of steel plants in the U.S. and Canada.

Vancouver, March meeting: Back Row, (left to right) J. H. Swerdferger, vice-chairman; Alan Kay, chairman, structural section; P. N. Bland, councillor; R. H. Carswell, treasurer; Commodore A. C. M. Davy, Western Field Secretary; J. E. Muir, student guidance; M. Lillie, membership; Front Row (left to right) W. G. Heslop, past chairman; C. P. Jones, chairman; J. J. Hanna; E. C. Luke.

Central B.C.

A. F. Joplin, M.E.I.C.,
Correspondent

LOCATING A SITE for the Dominion Radio Astrophysical Observatory's radio telescope at White Lake, Penticton, B.C., was the subject of a talk by Dr. J. L. Locke on April 22. The Director of the observatory described the search for a spot free from man-made electrical interference, sheltered by a natural bowl and close to a good sized community.

The main feature of the construction and operation of the telescope was an 84 ft. diameter parabolic antenna, according to Dr. Locke. He described the exploratory nature of the work done there, plotting electro-magnetic emmissions from space sources, analysing them, and collating information.

Eleven members from the Kootenay Branch were present.

The dinner meeting was held in the famous "S.S. Sicamous", the last C.P.R. paddle wheeler on the Okanagan Lake which is now berthed permanently on the shore at Penticton.

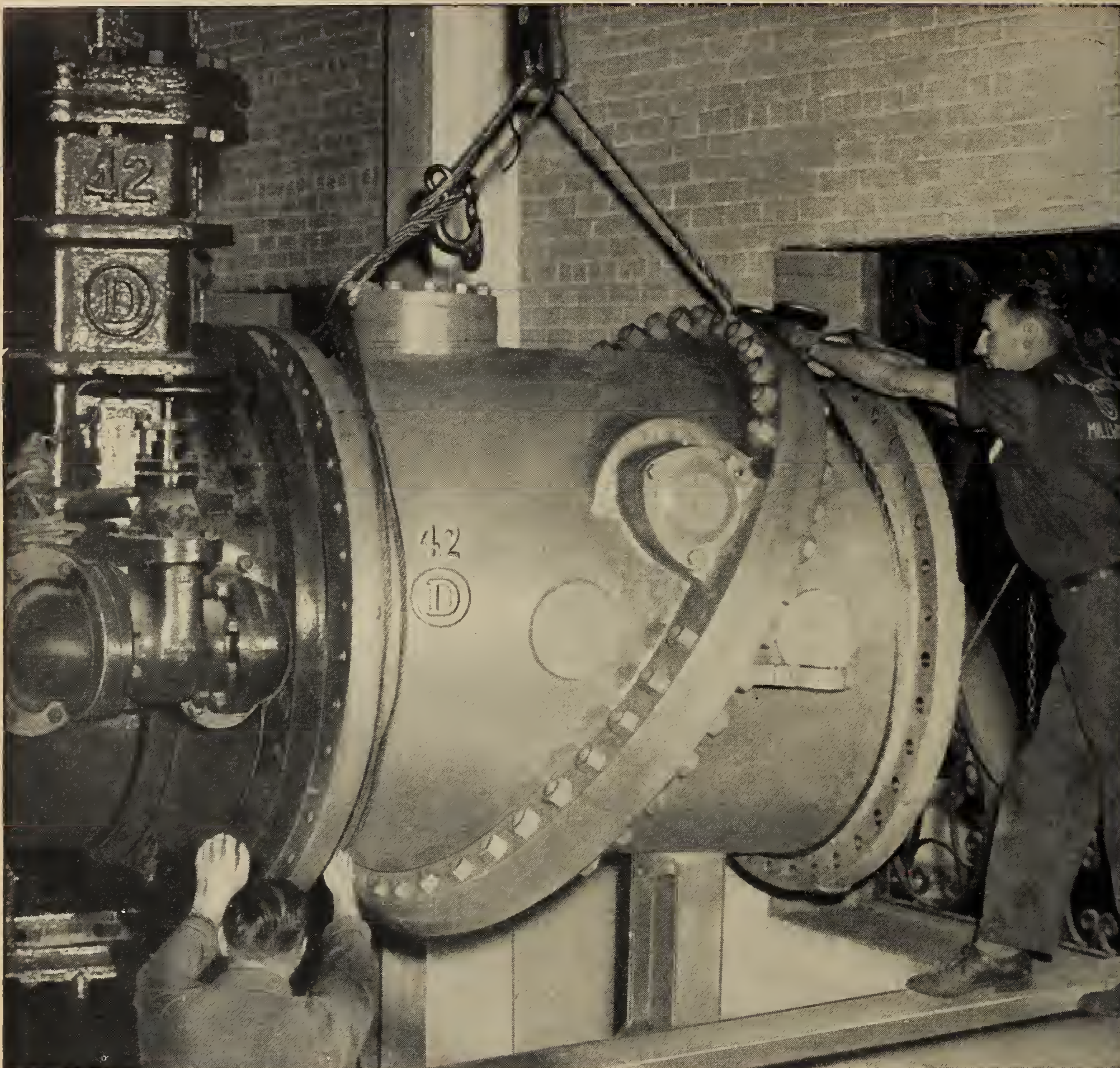
Chalk River

W. O. Findlay, M.E.I.C.,
Correspondent

E.I.C. PRESIDENT, Mr. J. J. Hanna, made a visit to the Chalk River Branch on May 2 and discussed Institute activities.

The new chairman of the branch is Mr. J. S. Flavelle, M.E.I.C., of the Eddy

(Continued on page 135)



Installing a Dominion Tilting Disc Check Valve at Montreal Waterworks

Dominion Tilting Disc Check Valves in cast iron or steel

feature

- ✓ STOCKED IN 3″ THROUGH 24″ SIZES
- ✓ MADE IN CANADA
- ✓ NON-SLAM DESIGN
- ✓ LOW HEAD LOSS
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Order tilting disc check valves specially engineered to your requirements from:

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DOMINION ENGINEERING

COMPANY LIMITED

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• BRANCH NEWS

(Continued from page 131)

Match Company; secretary, Mr. A. Kempe, Jr.E.I.C., of A.E.C.L.; treasurer, Mr. K. Smith, Jr.E.I.C., A.E.C.L.; membership, Mr. R. Sochaski, Jr.E.I.C., A.E.C.L.; program, Mrs. L. Larson, Jr.E.I.C., A.E.C.L.; and field representative, Lt. J. P. H. Richard, S.E.I.C., R.C.E.M.E.

Ecole Polytechnique

R. E. Miller, S.E.I.C.,
Correspondent

"THE STEEL INDUSTRY in Quebec" was discussed at the April 20 meeting by a group of four engineers, Mr. J. A. Retty, Ecole Polytechnique professor, Mr. G. Fauthier, Dominion Steel & Coal Company, Mr. Sibakin, Steel Company of Canada, and Mr. T. Hirst, Sogemines.

Mr. Retty talked about the iron ores of the Province; Mr. Sibakin, about the processes that could be applied in Quebec. On the other hand, Mr. Gauthier dealt with the possible use of our own Canadian coal, while Mr. Hirst made a survey of the future market. The general message was that although Canada would eventually produce coal, it would only be for certain limited uses.

Fredericton

John M. Burrows, JR.E.I.C.,
Correspondent

THE STUDENT PAPER COMPETITION, held on April 11, began with a presentation by Ralph Francis, senior civil engineering student at the University of New Brunswick, on the use of a Pratt Truss with one Vierendeel Panel in a unique problem of school construction. Bill Bearisto, senior electrical engineering student, U.N.B., presented the prize-winning paper, on the Reduction of Switching Centres on Digital Computers and John Ferris, senior civil engineering student, U.N.B., presented a paper on Aspects of Construction of the New C.P.R. Marshalling Yard at Lancaster, N.B.

Elected to office for the year 1960-61 were: chairman, M. Perlay Estey; vice-chairman, Eric C. Garland; secretary, Kenneth O. Bartlett; treasurer, G. D. Reeleder; executive members, R. J. R. Rogers, T. A. H. Gillis, E. J. Grant.

Hamilton

C. A. McCurdy, JR.E.I.C.,
Correspondent

"BEHIND THE SCENES in the Weather Office" was the title of a talk given by Mr. Percy Saltzman, Meteorologist, Dominion Weather Office, Toronto, at the April 20th meeting.

Officers of the Hamilton Branch for 1960-61 were presented to the membership. They are: chairman, P. J. McNally; vice-chairman, M. M. Kennedy; sec. treasurer, D. Friesen; executive committee, K. R. Crean, W. H. Hohn, W. A. H. Filer, and R. C. Monaghan.

Mr. J. H. Fox, M.E.I.C., the Lieutenant Governor's appointee to the A.P.E.O., attended the meeting and conveyed the greetings of the Association

Recent **Yukon** meeting: (left to right) Brigadier J. R. B. Jones, Commander, Northwest Highway System; J. J. Hanna; N. V. K. Wylie, Mayor of Whitehorse; Lt. Col. J. H. Reeves, chairman.

Kingston

D. I. Ourom, JR.E.I.C.,
Correspondent

"GROWTH OF AUTOMATA", an address by Dr. Arthur Porter, Dean of Engineering at the University of Saskatechewan, opened the May 7th Regional Technical Conference on Automation and Control at Kingston. Six papers were read in the afternoon including: *"A Numerically Controlled Positioning System"* by Mr. P. Hertzel of Sperry Gyroscope; *"The Application of a Small Digital Computer to Some Civil Engineering Problems"*, Mr. J. D. Lee of J. D. Lee and Co. Ltd.; *"Dead Reckoning Airborne Navigation Systems"*, Mr. A. Duguid, of Computing Devices of Canada; *"Instrumentation Problems in Hydro-*

gen Gas Generations", Mr. G. A. Locke and Mr. R. H. Andres, of Canadian Industries Ltd.; *"Logistics in the R.C.A.F."*, Air Commodore D. S. Blaine, R.C.A.F.; and *"Ferro-Electric Memory Devices"*, Officer Cadet R. B. Morris of R.M.C.

A reception and dinner-dance followed at the LaSalle Hotel in Kingston.

Kitchener

A. R. LeFeuvre, M.E.I.C.,
Correspondent

LADIES' NIGHT, the annual dinner-dance, was held on April 8th at the Westmount Golf and Country Club. Sixty-seven couples danced to the music of Ben Alexander's Orchestra and finished off a fine evening with a very bountiful buffet supper. The door prize and spot dance prizes donated by local firms added to the enjoyment of the evening.

Kootenay

I. Waterlow, M.E.I.C.,
Correspondent

THE HISTORY of radio astronomy was traced by Dr. J. L. Locke, Director of the Radio Telescope Observatory at White Lake, B.C., at a combined meeting of the Kootenay and Central B.C. Branches on April 22.


New Chairmen: (left) R. B. Walker, JR.E.I.C., Montreal, Junior Section; (right) B. I. Burgess, M.E.I.C., Quebec.

Radio astronomy began with the work of Dr. Karl J. Jansky who was engaged in study of static interference of the Bell System of Transoceanic Radio Telephone circuits from 1928-32. He discovered that a noise outside of earth came from a fixed direction out in space. Radar operators during the War also picked up noises that were not from earth. Since 1945 progress has been made in radio astronomy, beginning with small paraboloid collectors and arriving at models such as large-disk fixed collectors in the ground, the 220 ft. collector at Jodrell Bank, England, and the proposed 600 ft. collector being built in Virginia, U.S.A.

A. C. M. Davy, Western Field Secretary, was guest at this combined meeting.

London

G. T. Fenwick, JR.E.I.C.,
Correspondent

A.P.E.O. PRESIDENT, Mr. Dwight Simmons, spoke at the April 19th joint meeting, of E.I.C. and the Association of Professional Engineers of Ontario. Among the subjects of his discussion was the role of the employee-engineer.

Moose Jaw

T. S. Salmon, M.E.I.C.,
Correspondent

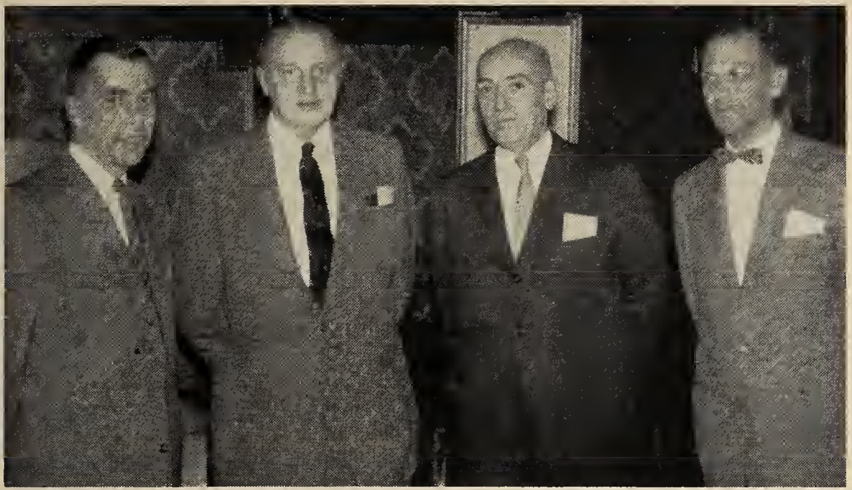
AIR PHOTOGRAPHY in engineering was discussed by Mr. Frank Patton, engineer with V. D. Mollard & Associates, at the May 11th Branch meeting. He explained that knowledge of both the geology and the topography of an area could be gotten from photographs and that this information in turn was valuable in selection of economical road routes; town sites; water supply from lakes, rivers, and ground water; dam sites; and materials for road building.

New officers for 1960-61 are: chairman, John MacKay; vice-chairman, Rod Grant; secretary-treasurer, Lloyd Salmon; officer-at-large, Mel Shelley.

Nipissing and Upper Ottawa

W. A. Adams, S.E.I.C.
Correspondent

A VISIT from President J. J. Hanna was the occasion of a branch meeting May 4th. He outlined the role of the Institute in preparing technical papers and lectures and forwarding development across the country. Mr. Hanna emphasized the need for more technical conferences. He also stressed the importance of engineers taking part in civic and community



Hamilton, winter meeting: (left to right) R. Stevenson, chairman; Mr. Brodie, speaker; C. O. Colbert, Bell Telephone, district manager, Hamilton; Bob Paton, evening chairman.

affairs.

This was also Ladies' Night and members and wives spent an enjoyable social evening at the White Oaks Inn, Temiskaming, Quebec. A cocktail party, compliments of Canadian International Paper Company Ltd., was followed by a sitdown supper, the president's address, and dancing.

Saguenay

Maurice Lavallee, JR.E.I.C.,
Correspondent

THE TOUR of the Hotel-Dieu St.-Vallier Hospital in Chicoutimi on April 25 was a highlight of the 1959-60 season. Approximately 60 members, their wives and friends were welcomed by Dr. M. Lapointe and taken through the Emergency Clinic, Operating and Recovery Rooms, the Cardiac Section, the Bacteriology and Blood Bank Sections, the Anatomy-Pathology Section, the Biochemical Section, the Physiotherapy and Rehabilitation Section, the Radiological Section, Library and Auditorium. Among the more fascinating sections was the department which dealt with heart functions and operations and the use of human "deep freeze" in them.

Saint John

Harley K. Larsen, M.E.I.C.,
Correspondent

A DINNER honouring the delegates to the National Convention of the Canadian Council of Professional Engineers held in Saint John May 11-13 was given by the Branch on May 12. D. O. Turnbull, a member of the E.I.C. Saint John Branch, is the 1959-60 President of the Dominion Council.

Sarnia

Paul Donato, M.E.I.C.,
Correspondent

THE PROFESSIONAL ENGINEERS' ACT, the Society of Ontario Hydro Professional Engineers, and the possibility of having area groups to contact engineers were discussed by A.P.E.O. President, Dwight Simmons, at the April 12 meeting. A resolution was proposed and adopted by the combined E.I.C.-A.P.E.O. group to form a committee of five to investigate the status of the Professional Engineer in the Sarnia area.

The Annual Ladies' Night was held at the Sarnia Golf Club, with a dinner and films from Dupont of Canada, on April 26.

Vancouver

C. H. White, M.E.I.C.,
Correspondent

"PLANNING AND THE ENGINEER" was the subject of a talk by Mr. J. W. Wilson, Executive Director, Lower Mainland Regional Planning Board, on April 26th. Opening with a plea to avoid professional arrogance, Mr. Wilson outlined the job of the planner. He stated that planning is essentially more of an art than a science. It is just now coming to first principles, he stated.

Special guests at the meeting were Mr. R. C. A. Stewart, Chairman of the Vancouver Branch of A.I.E.E., and Mr. William Leithead, President of the Architectural Institue of B.C. Thirty-six members and guests were present.

Elected to the 1960-61 executive were: chairman, J. H. Swerdfeger, M.E.I.C.; vice-chairman, C. H. White, M.E.I.C.; secretary, R. Clough, M.E.I.C.; treasurer, R. H. Carswell, Jr.E.I.C.; executive members, S. W. Faliszewski, D. R. Bakewell, and A. W. Greenius. The following will be filling the second year of their term as executive members: G. A. Antenbring, H. Lillie, C. H. Maartman, and A. A. Kay.

Yukon

J. P. MacGowan, M.E.I.C.,
Correspondent

A DINNER MEETING was held in the Inn Ballroom, Whitehorse, on April 21 in honour of E.I.C. President, J. J. Hanna. Approximately 30 E.I.C. members, branch affiliates, and members of the Association of Professional Engineers of the Yukon Territory were in attendance. Following the dinner, J. H. Reeves, chairman of the Yukon Branch, introduced Mr. Hanna.

The president stressed the need for humanitarian thinking in engineering and suggested that E.I.C. meetings should not always feature engineering discussions but should be varied to include topics of general local or national interest.

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*THEORY OF MECHANICAL VIBRATION.

This treatment of the theory of linear mechanical vibrations uses analytic principles to demonstrate the unity and coherence of the theory and its connection with other engineering sciences. Four sections cover systems with a single degree of freedom, systems with a multidegree of freedom and the concept of vibration modes, an extension of these results through matrix algebra and generalized coordinates, and the vibration of continuous media. Each part presents first the theory and principles, and a second section contains methods and applications. The principle of superposition, eigen-value problem in matrix, differential and integral equations, and energy methods receive special consideration. (K. N. Tong. New York, Wiley, 1960. 348p., $9.95.)

*NUCLEAR RADIATION ENGINEERING.

The fundamentals of atomic structure, the source of nuclear energy, and the principles of radioactivity are presented for the growing number of administrators who must be technically informed in their dealings with nuclear scientists and engineers. In serving as a primer for those who must speak the language and understand the problems of atomic science, it explains the atomic and nuclear causes of radioactivity, the kinds of radioactivity, the energy release associated with the process of radioactive disintegration. These areas, rather than reactor engineering, are of immediate concern to executives and supervisors of nuclear engineers. A dictionary of atomic and nuclear terms and phrases is included. (F. W. Hutchinson. New York, Ronald, 1960. 155 p., $6.00.)

*PHYSICAL METALLURGY.

Physical metallurgy is treated in terms of atomic processes and interactions, developing a comprehensive physical framework for metals and alloys. Experimental information is compared with the theoretical expectation in order to develop physical concepts that can be applied to real cases. Structure, properties, imperfections, deformation, change of state, and transformations are dealt with in turn, with the underlying theme that the behavior of a metal is determined by its properties and environment, and that these have been determined by its basic structure, chemical composition, and history. (Bruce Chalmers. New York, Wiley, 1959. 468p., $12.50.)

*ANALYSIS OF STATICALLY INDETERMINATE STRUCTURES, 4TH. ED.

Efforts made since 1943 to simplify and render more understandable the methods used in structural analysis are embodied in this fourth edition of a comprehensive text designed to provide a firm grounding in the basic principles and concepts of action of structural members subject to load. Presented are common methods of analysis of statically indeterminate structures in simple form, based on the fundamental principles of applied mechanics. Examples and practical problems illustrate the use of an analytical approach and induce development of problem-solving procedures. (C. D. Williams. Scranton, International Textbook, 1959. 360p., $9.25.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.
Library hours for June, July and August are: Monday to Friday: 2 p.m. to 5 p.m.; All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*ELECTRON PHYSICS.

The physics of the free electron is presented in two parts. The first contains a brief survey of methods for the production of electron rays as well as a detailed discussion of the main problems of electron motion; of electron optics, of the flow of electrons in dense space charges, and of the statistical fluctuations in low intensity beams. The second part deals with the fundamental properties of the free electron, namely its charge, mass, wave-length, spin, and magnetic moment. It also includes a description of the study of the free electron by quantitative methods. (O. Klemperer. Toronto, Butterworth, 1959. 248p., $7.00.)

*STRUCTURE AND PROPERTIES OF THIN FILMS

Proceedings of an international conference held at Bolton Landing, New York, in September, 1959, the review papers in this volume contribute to the areas of preparation, growth, and structure of thin films, and their mechanical, electrical, optical, and magnetic properties. A review of processes occurring at the metal surface is also given. Research papers present basic problems in physics and chemistry concentrating on ferromagnetism in very small specimens, the nature of chemisorption, and the effects of small dimensions on various properties. The use of thin films to obtain information about the bulk properties of matter, the investigation of properties of thin films which vary from properties of the same material in bulk form, the growth and characterization of thin films, surface chemistry, and the theory of surfaces are the fields covered. (Ed. by C. A. Neugebauer and others. New York, Wiley, 1959. 561p., $15.00.)

*INDUSTRIAL ELECTRONICS AND CONTROL, 2nd. ed.

A practical survey for the non-specialist, beginning with the theory of solid state conduction and leading to the theory of rectification and amplification via the semiconductor. Current practice in such applications as resistance welding and high frequency heating, and recent developments such as solid-state thyratons, cryotrons, and cold cathode vacuum tubes are covered, and there is new material on semiconductors, magnetic amplifiers, computers, electronic measurements and servomechanisms. (R. G.

A spot safety X-ray inspection of a Super Constellation aircraft tire, using Kodak type 'AA' film.

Kleoffler. New York, Wiley, 1960. 540p., $10.00.)

PRINCIPLES OF FREQUENCY MODULATION.

·An account of the basic principles of frequency modulation, the transmission of frequency-modulated waves, and the difference between frequency modulation, amplitude modulation, and phase modulation. Also covered are interference with f.m., the generation of f.m. waves, and the detection of f.m. waves. One chapter is devoted to the design of f.m. receivers, and another to the application of f.m. in microwave communication systems, radar, telegraphy and facsimile transmission. (B. S. Camies. New York, Rider, 1959. 147p., $3.50.)

HOW TO USE METERS, 2nd. ed.

In this revised edition, new material has been added on transistorized voltmeters, laboratory instruments with greatly increased sensitivities, specialized measurements and advanced meter features. Summary tables have been added for use in comparing meter types. The use of transducers in industrial electronics is also considered.

Information is given on the construction, operation and application of all types of electrical meters. There are many illustrations and diagrams. (J. F. Rider and S. D. Prensky. New York, Rider, 1960. 210p., $3.50.)

PRINCIPLES OF SURVEYING, 2nd. ed.

An introductory text covering the main principles and practices of plane surveying, intended for students. In this edition, the main change is the inclusion of six chapters in Part two on field astronomy, covering its methods and functions; apparent motions of celestial bodies; the celestial sphere; celestial co-ordinates; time; and astronomical observations. The first part of the book covers all aspects of plane surveying.

A companion volume deals with the principles and use of surveying instruments. (J. Clendenning. London, Blackie, 1960. 376 p., 30/-.)

APPLIED HEAT FOR ENGINEERS, 3rd. ed.

In the second edition, chapters were included on compressors and gas turbines, and in this third edition, a chapter has been included on refrigeration, which will be of interest to marine engineers. This volume is intended for an undergraduate text, and covers the basic physical principles of heat, and their application to heat engines. Numerous worked examples are included, as are problems, for which answers are provided. J.-B. O. Sneeden. London, Blackie, 1959. 380p., 25/-.)

FINANCIAL POST SURVEY OF MINES, 1960.

The first section of this survey contains a variety of information on Canadian mining companies and the industry, including an eight-year price range of stock prices, mineral production tables, metal prices, stock commission rates, and milling plants in Canada. Most of the volume is devoted to a geographical listing of all active mining companies, giving a wealth of information on each. Up-to-date maps of important mineral areas are included. (Toronto, Maclean-Hunter, 1959. 372p., $4.00.)

*NUCLEAR PROPULSION AND ENGINEERING FOR ENGINEERS.

The principles of nuclear energy and their application to aircraft propulsion are presented. The author discusses radio-activity associated with energy release; nuclear reactions as a source of energy release; neutrons as triggers of nuclear energy release; energy release characteristics of fission; neutron dynamics in propulsion reactors, steady operation of thermal neutron homogenous reaction and other type of reactors; unsteady reactor operation and control; and nuclear energy extraction and transformation. Since the use of materials and their modes of failure are of considerable importance, the author included a considerable amount of information on high temperature materials, heat transfer, creep, thermal fatigue, corrosion, oxidation, and thermal shock. Although only unclassified data is used, much useful information is included. (D. G. Samaras. Athens. Technical Chamber of Greece, 1955. 701p,. Price not given.)

*THE RADIO AMATEUR'S HANDBOOK, 37th ed.

This annual revision of a handbook written with the needs of the practical amateur in mind, maintains its objective of presenting the soundest and best aspects of current practice rather than the merely new and novel. Major revisions are in the sections on the theory of radiocommunication, construction of equipment, vacuum-tube characteristics, mobile radio equipment, and transistors. Other features are the manufacturers' catalog, instructions, abbreviations and country call-letters for station operation, and extensive vacuum-tube data tables. (West Hartford, American Radio Relay League, 1960, Various pagings, $4.00.)

*ELECTROMAGNETIC FIELDS, ENERGY, AND FORCES.

Emphasizing synthesis as opposed to analysis of fields, this book develops a consistent macroscopic theory of electromagnetism, including that of moving bodies. The process of electromechanical energy conversion is covered, and a power-series technique for analysing quasi-static fields and quasi-stationary systems is introduced. Appendices include material on the four-unit system of units used, and a four-dimensional relativistic fomulation of macroscopic electrodynamics. (R. F. Fano and others. New York, Wiley, 1960. 520p., $12.00.)

*ELECTRONIC CIRCUITS, SIGNALS, AND SYSTEMS.

The matrix, topological and signal-flowgraph methods of circuit and system analysis presented are specifically applied to electronic circuit problems. The analysis and synthesis of pulse, periodic and random signals presented is based on the correlation function and the Fourier integral and series, and transmission of signals through linear, non-linear, and time-varying-linear systems is investigated. The negative feed-back concept in electronic control also is discussed. (S. J. Mason and H. J. Zimmermann. New York, Wiley, 1960. 616p., $12.50.)

*APPLICATION DE LA GEOLOGIE AUX TRAVAUX DE L'INGENIEUR.

Intended for the consulting geologist and for the engineer faced with geologic problems in construction engineering. General geologic methods of terrain and subterranean exploration and documentation, including geophysics, boring and tunnelling are presented. Rocks above and below ground, their properties as natural formations and as building materials, and subterranean hydrology are studied. The final section deals with protective measures against earthquake, landslide, erosion, and heavy snow and wind. (Jean Goguel. Paris, Masson, 1959. 357p., 4300 fr.)

JAHRBUCH DER ELEKTROWARME, 1958/59.

This third year book of the electrical heating industry contains a series of review articles on various aspects of the industry, and problems connected with it, together with abstracts of articles appearing in German and foreign periodicals, and long bibliographies.

Some of the topics covered include: electric furnaces and heating used in various industries such as smelting, metal working, ceramics, wood drying, plastics and rubber; dielectric drying; chemical and technical problems; electric ovens; heat pumps; domestic and agricultural use. The last section of the book is a bibliography of articles from 244 periodicals. (Ed. by Harald Muller. Essen, Vulkan-Verlag, 1959. 628p., 68DM.)

MEHRFELDRAHMEN, bd. 1, 7. aufl.

This seventh edition of the author's well-known work previously entitled "Mehrstielige Rahmen," has been completely revised, and will now be published in three volumes. This first volume deals with formulae for any many-bayed, one and two-storied, immovable

(Continued on page 154)

Creative engineering opens new

GM DIESEL'S ALL-CANADIAN ENGINEERING TEAM SPARKS NEW ADVANCES IN POWER AND TRANSPORTATION ENGINEERING!

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Economical primary sewage plant designed with D-O-L equipment

Sewage treatment problems for an army camp are similar to those of many small communities. The aerial photo above shows how they are solved economically and efficiently by a small primary sewage plant installed at the Canadian Army Camp at Chilliwack, British Columbia.

Basic units are a Dorr Type MFC Digester, 30′ dia. x 16′ deep and a Dorr Type A Clarifier, 26′ dia. x 9′ side water depth. The plant is designed to handle 424,000 gallons of sewage per day. Choice of this Dorr-Oliver-Long equipment follows the example set by hundreds of municipal and industrial installations throughout Canada.

D-O-L offers a range of sewage treatment equipment to fit the needs of every type of plant, regardless of size, the kind of treatment desired, or the local conditions involved. For information on specific equipment items or for practical assistance on your particular problem, just drop a line to Dorr-Oliver-Long Limited, Orillia, Ontario.

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(Continued from page 145)

and elastically movable, continuous frames. It contains 50 formulae for frames with immovable supports and junction points, and 40 for frames with elastically movable continuous beams. (Adolf Kleinlogel and Arthur Haselbach. Berlin, Ernst, 1959. 460p., 68DM.)

DIE ZWEISEITIG GELAGERTE PLATTE: bd. 1. BIEGEMOMENTE UND DURCHBIEGUNGEN.

This first volume deals with bending moments and deflections of bearing plates, and includes a theoretical introduction, over 500 diagrams, and notes on them. A second volume will cover general applications, numerical examples, and tables. (Hugo Olsen and Fritz Reinitzhuber. Berlin, Ernst, 1959. 113p., 24 DM.)

FUNDAMENTALS OF GUIDED MISSILES.

An introductory text, this volume covers the theory, design, operation and maintenance of guided missiles. It commences with a glossary of guided missile terms, and a short history of guided missiles. Succeeding chapters cover aerodynamics, propulsion, instrumentation and control trajectory and guidance systems. There are many illustrations. (U.S. Air Force, Air Training Command. Los Angeles, Aero Publishers, 1960. 575p., $12.50.)

MEN AND MOMENTS IN THE HISTORY OF SCIENCE.

Nine essays reflecting the growing interest of scientists in the history of their fields, written by distinguished Californian scientists to celebrate the 25th anniversary of the History of Science Dinner Club at Berkeley. Some of the subjects covered include Stallo and the critique of classical physics; the history of science and the second law of thermodynamics; Planck's philosophy of science, Marco Polo's description of the world, and the first stellar parallax determination. (Ed. by H. M. Evans. Seattle, Univ. of Washington Press, 1959. 226p., $4.50.)

PRODUCTION TOOLING EQUIPMENT, 2nd. ed.

In this second edition of a text on the design of jigs, tools and gauges, the sections on ceramic tools and workshop and inspection gauges have been revised, and some material on 'throw-away' tool tips added. The first two parts of the book deal with the design of drilling jigs and fixtures, each one being discussed in relation to the component with which it is to be used. The third part deals with cutting tools, and tool layouts for production machines. (S.A.J. Parsons. London, Cleaver-Hume, 1960. 328p., 28/-.)

SANITATION, DRAINAGE AND WATER SUPPLY, 6th. ed.

Now completely revised, this volume shows the applications of developments in sanitary science to sanitary engineering. The subject is treated from the foundations to the completion of a building. It covers site and orientation of buildings; damp prevention; ventilation; water supply and central heating; drainage and sewage. It deals specifically with practices in the United Kingdom. (G. E. Mitchell revised by S. E. Thrower, London, Newnes, 1960. 198p., 30/-.)

A SIMPLE APPROACH TO ELECTRONIC COMPUTERS

An introduction to electronic computers, giving the basic working principles of both digital and analogue machines, and showing the advantages, disadvantages and uses of each. The first part deals with digital computers, and covers number representation, circuits, memory, control, input and output, programming and special purpose machines. The operation of analogue computers is discussed in the second part, together with chapters on basic circuits, and problem solving. (E. H. W. Hersee. London, Blackie, 1959. 104p., 12/6.)

CORRECTION

The book LIANTS ROUTIERES ET ENROBES: MATERIAUX DE PROTECTION . . . mentioned in the April issue of the Library Notes is published by Le Moniteur des Travaux Publics et du Batiment, 32 rue le Peletier, Paris 9e., and not by Dunod as was indicated.

(Continued on page 161)

● DISCUSSION

(Continued from page 101)

$ACBG^1$ will not be obtained in practice as the coefficient of permeability the tunnel lining will always be less than the grouted rock. Therefore immediately after dewatering the pressure on the lining is represented by FD^1 and as the flow of water develops the pressure will drop to DD^1. It would appear that the grouting of the rock cannot be relied upon to diminish the external water pressure by a large amount and it would be preferable to strengthen the tunnel lining. It may be argued that the grouted rock and the tunnel shell will act as a single structural unit in resisting the external pressures. It is my opinion that this action should not be relied upon and in any event the water will still penetrate through the grouted rock to the tunnel shell.

Secondly, it was stated that hydraulic models were used during the design of the intake tunnel. However the authors failed to mention the scale to which the models were constructed.

As Messrs Matthias, Travers and Duncan are no doubt aware the similitude of the forces in the model and the prototype depend upon the Froude number and the similitude of the velocity profiles depends on the Reynolds Number.

To satisfy both criterions simultaneously is usually impossible and the scale selected for the model is a compromise. The writer is curious to know the scale of the models used for the design of the intake. It is not stated either if the models used were two or three dimensional. If two dimensional models were used then the model results give only a rough guide as to the nature of the flow to be expected in the prototype.

It would be appreciated if the authors would be good enough to clear up these points.

Author's reply by F. J. Travers

We have read with a great deal of interest the observations made by Mr. Dick on the question of grouting the rock surrounding the concrete lining of the tunnel at Chute-des-Passes.

We agree with the analysis which Mr. Dick has presented concerning the behaviour of water in rock below the phreatic line with respect to concrete tunnel linings. It was not the intention of the authors to convey the impression that, in theory, grouping will prevent water under high pressure from acting on the tunnel lining when the tunnel is dewatered. However, there are practical effects which are associated with grouting the rock surrounding the lining of the tunnel which modify theoretical considerations.

If the tunnel lining, compared to the rock, is relatively impervious, undoubtedly water pressure will build up behind the lining when the tunnel is dewatered. If the tunnel lining and surrounding rock are porous, any water in the rock will certainly begin to flow toward the emptied tunnel. If the flow of water through the rock can be reduced, and if the tunnel lining provides adequate means of escape for the water, it follows that high water pressures can not be built up behind the lining. Where a water bearing strata of rock is encountered, successful grouting will restrict the flow of water to the back of the concrete lining. Water entrapped between the interface of the concrete lining and the rock can usually find avenues of escape through openings in the concrete, such as small cracks which are inevitably formed in unreinforced concrete, thereby relieving any water pressure which may build up behind the lining.

The hydraulic models mentioned in the paper were three-dimensional. A large topographical model, which incorporated the intake opening at the bottom of the reservoir and included the intake tunnel and intake structure, was made to a scale of 1 inch=5 feet. The main purpose of this model was to observe the action of the water approaching the intake opening and also to provide sufficient data in order to design the shape of the intake opening.

A second model, built to a scale of 1 inch=6 feet, was arranged so that observations could be made in order to predict the behaviour of the rock and water rushing into the intake tunnel immediately after the rock plug was blasted. Through the use of this model, it was possible to design a large sump to catch the broken rock and also to predict the forces which were imposed on the intake structure by the inrushing water after the plug was breached.

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PROFESSIONAL ENGINEER with successful record as Assistant Production Manager, Chief Engineer, Plant Engineer seeks position medium, small company, consulting firm where wide knowledge of industrial methods, management, plant construction, layout, machinery, plant services can be used to improve and expand the business. Responsibility, challenge desired in place of security benefits. Long term prospects more important than immediate salary. Limited investment possible. Located Atlantic Province. File No. 5734-W.

INDUSTRIAL ENGINEER (Holland) Jr. E.I.C., age 32, married. Interested in permanent position as plant engineer with medium size company. Seven years' experience in plant efficiency, production planning, maintenance and technical sales. Present location Central Canada. Detailed resume available upon request. File No. 5754-W.

MECHANICAL ENGINEER, P.Eng., B.Sc., Jr.E.I.C., age 41, married. 10 years' experience includes quality control, design and maintenance engineering in rubber and chemical industries, in heating, ventilating and automatic control fields. Looking for a more responsible position in a small or medium size progressive industry. Location preference Southern or Central Ontario. Resume and references on request. Located Central Canada. File No. 5797-W.

CIVIL ENGINEER, M.E.I.C., P.Eng., (Ont.). B.A.Sc. University of New Brunswick, 1950. Age 31, married with family. Ten years' experience in construction industry, five in field, including two years as superintendent, and three in office management position. Seeks position with contractor, eventually becoming partner or associate. Located Central Canada, but willing to move anywhere except Montreal or Toronto. File No. 5813-W.

PROFESSIONAL ENGINEER, JrE.I.C., P.Eng. (Ontario) B.A.Sc. Toronto 1954 (Civil). Age 28, married, no children. Experience: 2 years municipal field work and 4 years in pulp & paper industry (plant maintenance, design, layout and construction). Seeks responsible position in industrial or construction fields. Locaton preferred, Southern Ontario. Located Central Canada. File No. 5836-W.

PROFESSIONAL ENGINEER, B.Sc. E.E., 1946, M.E.I.C., age 37, married, family. Presently District Manager Western Canada, sales and service of highly technical products utilized by industrial and utility accounts. Desres change. Seeking challenging position with progressive company in planning, promotion, organization, sales or management. Located Prairie Province. File No. 5866-V.

ENGINEERING EXECUTIVE, M.E.I.C., M.A.S.C.E., M.A.S.M.E., B.S., Ch.E., Illinois Institute of Technology. Seeks relocation General Manager smaller firm requiring all around engineering, business know-how, or as Regional Representative, Project Manager of larger organization, consulting firm. Professionally recognized administrative, organizational leadership skills. Adept at public relations, dealing with problems, people at all levels. 20 years solid well rounded experience. Widower, 3 children. Location U.S.A. File No. 5874-W.

PROFESSIONAL ENGINEER, M.E.I.C., with 20 years' experience in mechanical, structural and electrical fields seeks leading place in design engineering. Location Central Canada. File No. 5875-W.

CIVIL ENGINEER, P.Eng. (Ont.), Jr.E.I.C., B.Sc. Queen's 1949. Married with family, age 35. Experience includes three years' design and five years as field engineer in supervisory capacity on extensive capital expansion programmes with large pulp and paper firm. Desire more responsible position in above or allied industry or in municipal engineering field. Full resume on request. Located Central Canada. File No. 5876-W.

CIVIL ENGINEER, Jr.E.I.C., B.Sc. C.E., P.Eng. Ont., age 30, married. Six years' experience in highway design, construction, and traffic analysis. Two years' experience in hydrometric work. Presently employed in a supervisory position in Central Canada. Desires to Locate in Western Canada. File No. 5877-W.

CIVIL ENGINEER, P.Eng. (Ont.), M.E.I.C., B.Sc. 1948. M.Sc. Age 34 with more than 12 years design and general experience of building, structural, municipal, bridge and highway work. Wishes to associate with a consulting engineer, architect etc. Preferred location Toronto or Southern Ontario. Located Central Canada. File No. 5878-W.

MECHANICAL ENGINEER, Jr.E.I.C., B.A.Sc., Toronto 1950, age 32, married, one child, bilingual. Ten years' general and industrial engineering experience with private electric utility company, including preparation of specifications, approval of drawings, inspection, special studies; 1½ years on assignment in Europe dealing with hydraulic turbines, governors and model studies. Seeking development, project or industrial engineering work. Located Central Canada. File No. 5879-W.

CIVIL ENGINEER, M.E.I.C., wishes to represent manufacturer as a sales engineer or manufacturer's agent in the Maritime Provinces. Now located in Fredericton, N.B., with an office and staff doing general engineering work. File No. 5880-W.

MECHANICAL ENGINEER, Jr.E.I.C., P.Eng., (Ont.), Queen's '52, age 38, single. Four years' maintenance engineering in petro-chemical industry, three years plant engineering in aircraft industry. Past year employed as plant engineer with small manufacturing company. Seeks position with medium or large organization. Prefer Southern Ontario location. Located Central Canada. File No. 5882-W.

CIVIL ENGINEER, Ontario land surveyor, Jr.E.I.C., P.Eng., Ontario, B.Sc. Queen's University, age 28, married, experience in road design, construction, municipal engineering, drainage, land surveying. Seeks challenging position in sales or supervision. Located Central Canada. File No. 5884-W.

ELECTRIC ENGINEER. B.Sc. (N.S.T.C.) M.E.I.C., P. Eng., married. Experience: Nine years' electrical inspection. Eleven years electrical contracting. Interested in design of installation and/or inspection work. Details of experience furnished upon request. Located Atlantic Province. File No. 5885-W.

PROFESSIONAL ENGINEER, Jr.E.I.C., (Mining), 8 years' experience including, surface construction, mine survey, mine planning and layout, and general office work. Looking for a position as industrial engineer in a progressive company. Ready to start at the bottom. Location preferred: Province of Quebec. Located Central Canada. File No. 5886-W.

MECHANICAL ENGINEER, S.E.I.C., McGill 1960, age 24, single. Interested in design, production of instrumentation, hydraulic-pneumatic controls, actuators and general mechanical machinery. Montreal area preferred. Located Central Canada. File No. 5890-W.

GRADUATE MECHANICAL ENGINEER, Jr.E.I.C., seeks a responsible position in

● LIBRARY NOTES

(Continued from page 154)

°VALUE ENGINEERING, 1959.

The basic concepts and philosophies, techniques and applications of value engineering are contained in these papers, originally presented at the Electronics Industries Association Conference on this new engineering specialty, held at the University of Philadelphia in October 1959. Categorizing engineering of the past as "Performance Engineering," or the development of a product to perform a service required by a recognized need, with secondary attention to costs, proponents of value engineering see it as fulfilling the demands of the present era by providing techniques which will vastly reduce costs of present products and evolve better products for known needs as well as by searching out new needs. (New York, Interscience, 1959. 165p., $6.00.)

ASBESTOS; ITS ORIGIN, PRODUCTION AND UTILIZATION, 2nd. ed.

A comprehensive account of asbestos from its source to its end-use, covering types of asbestos, world distribution, mining, milling, commercial application, and substitutes. In this second edition, various minor additions and revisions have been made, and the statistics and lengthy bibliography brought up-to-date, but the most significant change is the addition of three chapters reviewing the Canadian asbestos industry, the location of deposits, and mining and milling practices. There is also a chapter surveying the industry in the United States. The author visited both countries recently. (W. E. Sinclair. London, Mining Publications, 1959. 512p., £3.)

WORLD ALMANAC, 1960.

Now in its 75th year, the Almanac for 1960 covers the main events of 1959, including the opening of the St. Lawrence Seaway, the political changes in the Caribbean, the rise of nationalism in Africa, scientific progress, etc. All the usual Almanac sections are included, information on everything from Amateur athletic champions to Zoological parks. Although the emphasis is generally on United States statistics, no library can afford to be without this useful reference tool. (Ed. by Harry Hansen. New York, World Telegram and Sun, 1960. 896 p., $1.35.)

°THE AERODYNAMICS OF POWERED FLIGHT

Using analysis of rocket thrust as a logical means of introduction to aerodynamics, the author provides a foundation in fluid flow and airfoil theory by developing the concept of lift and drag in incompressible flow, compressibility effects in subsonic flow, shock-wave formation, and super-sonic flight. He introduces the fundamentals of propulsion and propeller analysis, stability, performance and manoeuvering flight, design and testing, and control. The mathematical

(Continued on page 180)

● MORE WINNIPEG PICTURES

The Winnipeg Committee that handled the 74th Annual General Meeting.

There were many visitors to the Library exhibit—but copies of most papers read at the Meeting can still be obtained from the Engineering Institute library.

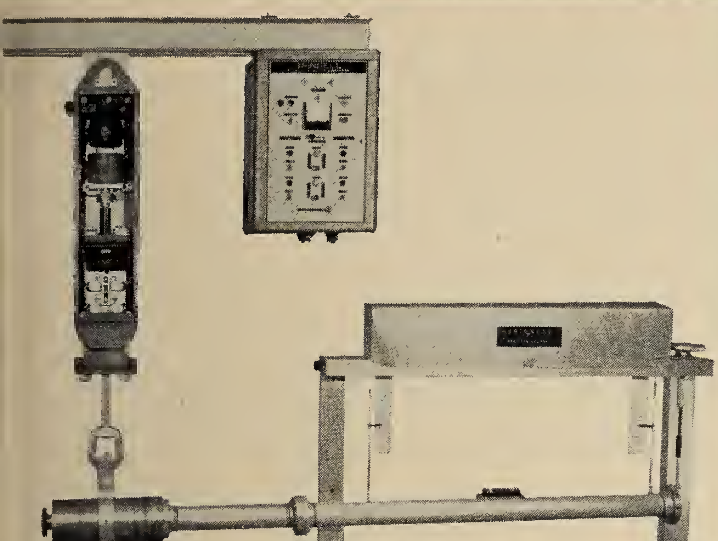
Council listens to Mr. John Fox, who delivered the report of the Engineers Confederation Commission.

(Left) The two Presidents with members of the new Council.

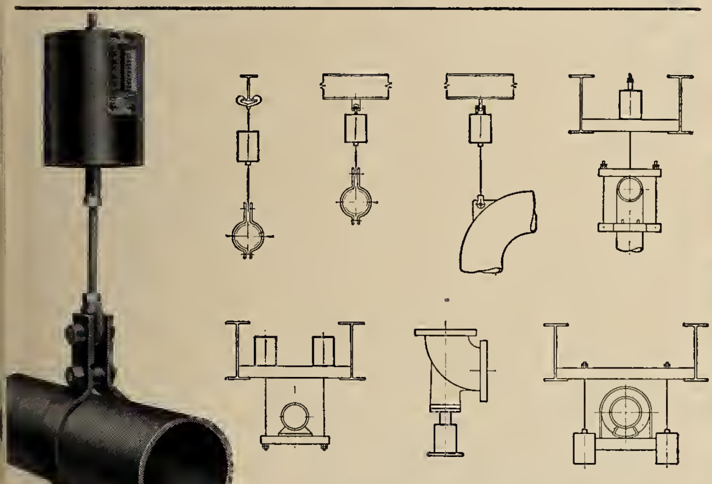
Mrs. G. M. Dick chats with a past president of the Institute, Dr. C. J. MacKenzie, at the reception preceding the Annual Dance.

The Committee on Technical Operations (Chairman, Dr. Guy Ballard).

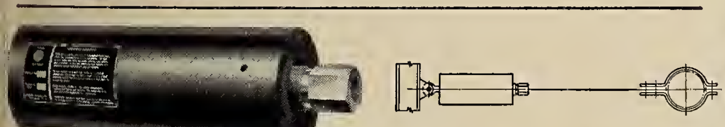
hangers to provide for thermal expansion



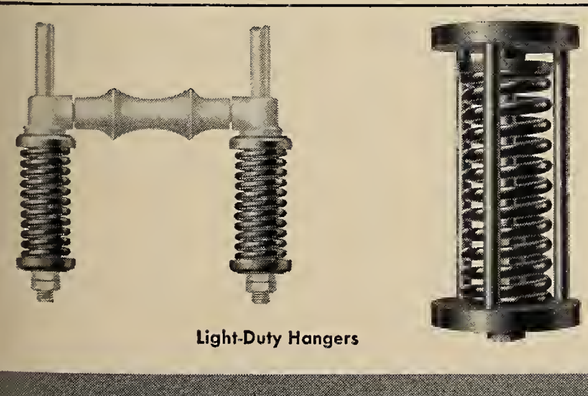
Stress-Trol



Variable Spring Hangers and Applications



Vibration Control and Sway Brace



Light-Duty Hangers

GRINNELL STRESS-TROL* FOR POSITION AND/OR LOAD CONTROL

Keeping the footage of high pressure-high temperature fabricated piping to a minimum has become important because of high piping costs. This can be accomplished by reducing the length of long expansion bends, but providing support for shorter, less flexible lengths of piping presents a new problem. Grinnell Stress-Trol, a motor operated device, solves this problem. It provides:

> **Position Control** — that minimizes stresses in piping and reactions on connected equipment.
>
> **Load Control** — that is constant support with unlimited load and travel capacities.

GRINNELL VARIABLE SPRING HANGERS

When pipe lines are subject to relatively small vertical movement, and do not require a constant support type hanger, Grinnell Variable Spring Hangers are available. The maximum variation in supporting force for standard spring models per ½ inch deflection is 10% of rated capacity. Grinnell offers these hangers in 21 sizes — in short, standard and double spring models, plus a special corrosion-resistant model. There are 7 different methods of attachment.

GRINNELL VIBRATION CONTROL AND SWAY BRACE

When necessary to prevent undesirable movement in lines, Grinnell Vibration Controls and Sway Braces of the energy storing and instant-acting counter force type are recommended. They dampen vibration, oppose pipe sway and absorb shock.

GRINNELL LIGHT-DUTY SPRING HANGERS

Finally, simple and inexpensive adjustable light-duty spring hangers often are all that's required to support piping safely. Grinnell has a complete line of light-duty hangers. They are designed for easy installation and quick, accurate alignment of piping.

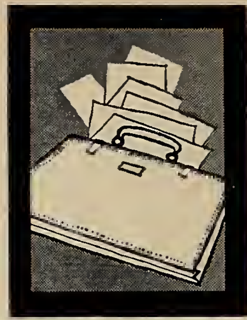
Grinnell Company of Canada, Ltd., Edmonton, Montreal, Toronto, Vancouver, Winnipeg.

**Patents Applied For*

GRINNELL

BRANCH WAREHOUSES AND DISTRIBUTORS IN PRINCIPAL CITIES

Business and Industrial Briefs



Appointments and Transfers

The Directors of IPEC — the new corporate name of B.C. & B.B. Power Consultants Limited of Vancouver — are as follows:

Sir Andrew MacTaggart, K.B., Chairman of the Board; A. E. Grauer, LL.D., Deputy Chairman of the Board; T. Ingelow, D.Sc., President and Chief Executive Officer; H. W. Smith, Executive Vice-President; K. H. Kidd, Vice-President; W. I. O'Hara, Vice-President; Sir Thomas Foy, K.B., Director & Consultant; A. B. Robertson, Q.C., Director; R. H. R. McGill, Director.

A. L. Pike has been appointed manager of the Vancouver office of Sheldons Engineering Limited.

G. B. Wood has been appointed Sales Manager of the Steambloc Division of Babcock-Wilcox and Goldie-McCulloch Limited. He will direct the marketing program for the B&W packaged boilers throughout Canada.

Canadian Allis-Chalmers announces three appointments: J. C. Slingsby becomes assistant general manager of St. Thomas Works, G. C. Windeler replaces Mr. Slingsby as manager of the Vancouver office, and he is in turn replaced by E. N. Payne as manager of the Moncton office.

The Steel Company of Canada has appointed Lee T. Craig and Harold M. Griffith to its Board of Directors. Mr. Craig, who has been with the Company since 1920, is vice president of sales. Mr. Griffith, vice president of operations, joined Stelco in 1936.

Arthur K. Howe has joined the technical service department of Sika Chemical Corporation, Passaic, N.J. to assist architects, engineers and contractors with specific technical inquiries on concrete construction and maintenance.

Henry S. Wingate, President of International Nickel since 1954 and a director since 1942, has been elected Chairman of the Board and Chief Officer of the Company.

New Developments

WATER AND SEWAGE works pose a concrete problem because of severe weathering, freezing and thawing, saturation with water and chemical corrosion. Studies of 35 installations are contained in a Master Builders Company publication, documenting the performance of Pozzolith under operating conditions.

RAMP HANDLING for KLM DC7C's and DC8 jets, and freight handling for the airline's Constellation 1049 freighters, will be provided by Bristol's Aviation Services at Montreal, under a contract recently signed.

PERIMETER BLASTING is the name of a new technique introduced to Canada by CIL. Producing remarkably clean-cut rock walls, it is in use in the construction of defense installations and is expected also to assist in mining and the driving of hydro tunnels.

VANCOUVER is to have a second Kodak processing laboratory in Canada. Some 1600 persons are at present employed in the Toronto operations of this company. The new building will have 23,000 sq. ft. of floor space and is expected to be ready to accept film in April, 1961.

GOING CRITICAL at 12.33 AM Saturday, March 26, Oak Ridge National Laboratory's newest reactor, Tower Shielding Reactor II, replaced its predecessor in the work associated with studies of radiation scatter, part of the development of a safe nuclear-powered aircraft engine. Many of these studies require that the reactor be suspended in the air as high as 200 feet. TSR-II is a tank-type heterogeneous reactor, moderated and cooled with demineralized light water, and designed to operate at five thermal megawatts. The core is at the lower end of an aluminum tank, three feet in diameter and eight feet long, which can be suspended from four 324-foot towers.

JET LANDINGS mean fast speeds, long run-outs and, consequently longer taxi runs to and from the hangar. These long distances create more fatigue cycles which generate a high heat build-up and thereby reduce the strength and life of the tire. Goodyear has simulated all these stresses on a new $2 million multi-stage dynamometer system to qualify tires for the aircraft of the future.

NICKEL DEMAND is expected to continue high. Work on its applications is now on a more highly organized and efficient world-wide basis, according to Dr. John F. Thompson, Chairman of the Board of International Nickel. He believes these efforts will lead to absorption of the new nickel supplies and to a progressive decade in the industry.

LOW COST and versatility are features of a new G-E time switch designed for regular duty indoors on advertising signs, floodlighting, heating, air conditioning, refrigeration and motor starting. The 24 hour dial can be used for 12 on-off operations in one day with trippers set as close as one hour apart.

STAINLESS STEEL bonded to plywood forms the exterior walls of an experimental house recently erected at Woodbridge, Ont. It was built by Arctic Units Limited for Thomas Ibronyi, an architect who is writing a thesis for his Master's Degree on building in the Arctic. He wished to show that economical prefabricated buildings can be mass produced for use either in the north or in temperate climes.

• *More Briefs on pages 174, 179*

The excellent shearing action, with traces of boreholes still visible, clearly indicates minimum shock, a firm solid back and safer working conditions. At Lamaque, where this explosive was first tested, scaling and set-up time has been reduced to the extent that 13 ft. stope rounds can now be drilled and blasted compared to 9 ft. formerly.

• MORE BRIEFS

MARQUETTE UNIVERSITY is to conduct a comprehensive home study course in business administration that Canadian Allis-Chalmers are offering to all their management employees. Subjects treated will include economic theory, the corporation, personnel management, managerial techniques, production and marketing.

GAS TURBINES for natural gas transmission have been ordered by Trans-Canada Pipe Lines. Canadian Westinghouse will make the three 8500 horsepower units which are to act as compressor drivers for the export line to the U.S. The turbines are modified for wide variations of temperature and load.

AS A CHOPPER the symmetrical transistor was thought to have disadvantages such as a need for accurate setting-up beforehand to obtain a low and constant rate of drift with temperature change. Smiths Aviation Division has developed a way for using the transistor, principally for use with thermocouples, with setting up obviated or in some cases reduced to a minimum. Performance can be guaranteed from a standard batch of transistors and the company also visualizes the use of this transistor chopper technique in strain-gauge work.

FIRE AND EXPLOSION because the leg belt slips on the drive pulley is a hazard that has worried grain terminal elevator operators for many years. If the boot becomes choked with grain and causes slipping, friction at the pulley soon produces excessive heat. Measurement Engineering Limited, of Arnprior, Ont., have introduced the Slipmonitor, a simple device installed without modification to leg belt or housing to operate an alarm or shut down the drive motor when belt slipping reaches a preset point, normally 20% of regular speed.

FLEXIBLE CONDUIT produced in a variety of materials was displayed at the Pipes and Pipelines Exhibition in London, England, by Plessey, the manufacturers of "Plessiflex". The "Plessiflex" hose can be used for refrigerant lines and for the conveyance of fluids and gases including corrossive chemicals and hot air for pressure and vacuum installations. It can be produced in stainless steel, mild steel and brass, high purity nickel, high purity aluminum, Monel and Inconel.

OIL HEAT will be more popular if new units increase its efficiency. To this end, Shell offers its new oil burner design royalty-free and will consult with burner manufacturers who are actively pursuing this improvement.

PLYWOOD RESEARCH and promotional efforts are being increased in British Columbia to meet the threatened invasion of traditional markets by new competitors. The plywood manufacturing industry has steadily grown during the past year, but competition is increasing the urgency of new use for the material, and research in the engineered components field is being expanded.

PUMPS AND VALVES have been the concern of Smart Turner of Hamilton, Ont., and of Klipfel Valves of Hamilton, Ohio, for over half a century. These two organizations have now joined forces to extend distribution and services and offer their customers a more diversified line of products.

LONG CRAWLERS are standard on the B-425, Dominion Engineering's new 1¼ cu. yd. capacity pullshovel. The shovel boom is 22 ft. 6 ins. long and the standard dipper sticks have an effective length of 16 ft. 4 ins.

CORRECT PRODUCTION HOURS for a single operation or a series are shown by the Van D. Mark Machine Load Calculator, devised for quick translations of production quantities and rates into shop loads. One setting of the two discs shows the hours needed, and there is no worry about decimal points. Calculator scales are clear and cover a wide range of figures, although only six inches in diameter.

OVER 1,200,000 hp. has now been delivered by General Motors to the C.N.R. The 1000th diesel-electric locomotive was recently delivered to the railway by General Motors Diesel, who during the past ten years have delivered 1740 units, amounting to over 2,500,000 hp., to thirty customers.

NO LONGER than a cigarette filter, a miniaturized synchronous a-c timing motor has been manufactured by The A. W. Haydon Company for application where reliability performance and space are of prime consideration. Designated as the 42100 Series Commercial 60-cycle a-c Timing Motor, this five ounce device provides extremely fast starting and stopping, eliminating prestarting and clutching in many uses. This light weight motor may be employed in the delay relays stop clocks or other custom designed timers, as well as in chart drive and control equipment.

ULTRA-SONIC DETECTION of bubbles is possible through a new device offered by Taylor Instrument Companies of Canada Limited. The apparatus, which can be used in almost any liquid, in open or closed vessels or in pipes, consists of a sensing head assembly connected by a continuous loop cable to an amplifying unit. A pulsed ultra-sonic signal passes through the liquid flowing between transmitter and receiving heads, and the presence of bubbles weakens or interrupts the signal.

NON-COHESIVE MATERIALS such as sands and gravels can be tested for density at construction sites in the field with a new apparatus being produced by Soiltest Inc. The device was originally developed by the U.S. Corps of Engineers at Providence, R.I. to perform what is now known as the Providence Density Test. Oven-dry samples and placed in a cylinder and a spring arrangement applies a 1000 lb. load. Hammering the outside of the cylinder then vibrates the test materials into a more confined volume, and the number of blows required for their maximum compaction is correlated with density. The tester is light enough for one man to carry.

• *More Briefs on page 179*

Consulting Services

• MORE BRIEFS

WESTINGHOUSE has issued a new compact catalogue for its industrial apparatus, with selector guides, characteristics and prices on motors, controls, industrial circuit breakers, safety switches, bus duct, panelboards, load centres, large air circuit breakers, dry type transformers and lighting.

CRTPB, the Canadian Radio Technical Planning Board, is inviting applications for membership. Its committees handle such problems as frequency allocations, interference, equipment specifications, procedures, amortization periods and effective dates. The problems involve all classes of electronic communications equipment and systems as well as industrial, scientific and other apparatus employing radio principles and utilizing the spectrum or possibly interfering with its effective use.

WRITING SPEEDS of 100,000 in. per sec. are possible with Kodak Linagraph Direct Print Paper, a photographic material which provides an immediately visible record of certain oscillographic tracings. The paper yields an image without chemical processing and can record through a wide range of operating frequencies.

INFRA-RED OVENS with greatly improved efficiency and appearance are announced by Canadian General Electric. There are no interior structural members. Aluminum baffles reflect heat on to the articles to be dried, baked or cured. Reflectors, heating elements and baffles are supported entirely by the steel sheet shell of the oven.

ANY VARIABLE that can be measured electrically can be indicated, monitored and controlled by the API meter-relay, model 255-C, marketed in Canada by Aeromotive Engineering Products Limited.

SILICONES enable so many materials of design and production to resist time, heat, cold, moisture, weathering, oxidation, electricity and chemical attack, that Dow Corning has completely rewritten its Engineering Guide for Silicones.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

The Canada Cement Company, Limited advertisement on page 41 of the March issue was judged the "best" in that issue by a fifty reader jury. Judging was made from the viewpoints of ACCURACY—INFORMATION and ATTRACTION. The advertisement is headed: "Safe, sound, smooth: CONCRETE chosen for Quebec's Laurentian Autoroute."

The copy states, concisely, the advantages of concrete for road surfacing emphasizing the all-Canadian aspects of Canada Cement and offers technical literature covering the use of cement. The advertisement is in black and white.

Each month the Engineering Institute of Canada asks fifty different readers to judge the advertisements. Their names are taken from the "Journal" distribution list in such a way that all provinces are represented so that a good cross-section of opinion will be obtained.

The Advertising Manager of Canada Cement Company, Limited is Mr. John V. Tittley and the advertisement was prepared and placed by Cockfield, Brown & Co. Ltd. Montreal.

CANADA CEMENT COMPANY, LIMITED WINS CERTIFICATE OF ADVERTISING MERIT

Reproduced below, on a reduced scale, is the black and white advertisement of Canada Cement Company, Limited, which was judged the "best" in the March issue, from the viewpoints of ACCURACY—INFORMATION and ATTRACTION. The advertisement features the use of concrete for surfacing the new Quebec Laurentian Autoroute.

• LIBRARY NOTES

(Continued from page 161)

approach is simple without being too elementary, and problems are given at the end of each chapter. (R. L. Carroll. New York, Wiley, 1960. 275p., $8.50.)

ATOMIC ENERGY IN THE COMMUNIST BLOC.

A carefully compiled account of industrial nuclear developments in the Soviet bloc. The author points out that there are three types of developments: in the U.S.S.R. itself, the spread of nuclear techniques from the military to the industrial field; in the satellite countries of Eastern Europe, the launching of nuclear programmes in economically well-developed countries; in China, the drive for nuclear expansion in a country technologically backward. The author considers Soviet administration of atomic affairs, Soviet nuclear research, nuclear power plans, nuclear resources, co-operation within the Soviet bloc, research programmes in Eastern Europe, the nuclear situation in China. The author has included bibliographical footnotes. (G. A. Modelski. Melbourne, University Press, 1959. 226p., $5.75.)

ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES AND THEIR USES, 2nd. ed.

Brought up-to-date and greatly expanded, the Encyclopedia commences with several chapters on the theory of operation and the basic construction of cathode-ray tubes. The second section is concerned with oscilloscope circuitry and operation, commercial scope types and maintenance. Applications considered include pulse measurement; transmitter testing; engineering, medical and scientific applications, and oscilloscope photography. There is one chapter of specifications and schematics of commercial oscilloscopes, both U.S. and foreign, and there is an eleven-page bibliography. This is indeed an encyclopedic work. (J. F. Rider and S. D. Uslan. New York, Rider, 1959. about 1350 pages, $21.95.)

THE TECHNICAL INSTITUTE IN AMERICA

The results of a survey made in 1957-1958 to reveal the status and potential of technical institute education in America. The volume is a compilation of facts and opinions on the educational and employment practices relating to the engineering technician as the demand for technological manpower has grown. After a brief historical background, the survey covers the objectives of the technical institute, its curriculum, students, faculty, physical plant, administration, and financial structure, and problems. It also considers the employment opportunities of the engineering technician. (G. R. Henninger. Toronto, McGraw-Hill, 1959. 276p., $6.90.)

NOTE: During the months of June, July and August Library hours are Monday to Friday, 2 p.m. to 5 p.m. only.

THE ENGINEERING JOURNAL
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MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science
and Technology Index

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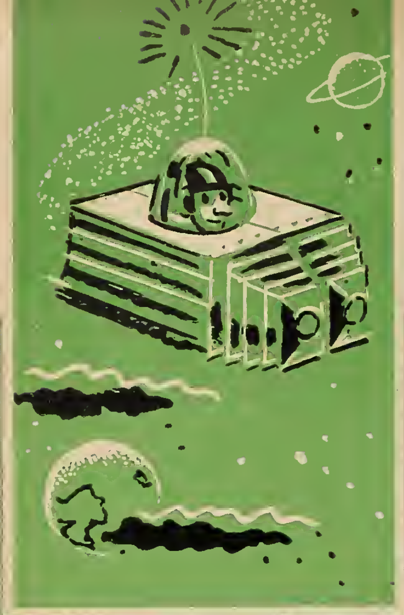
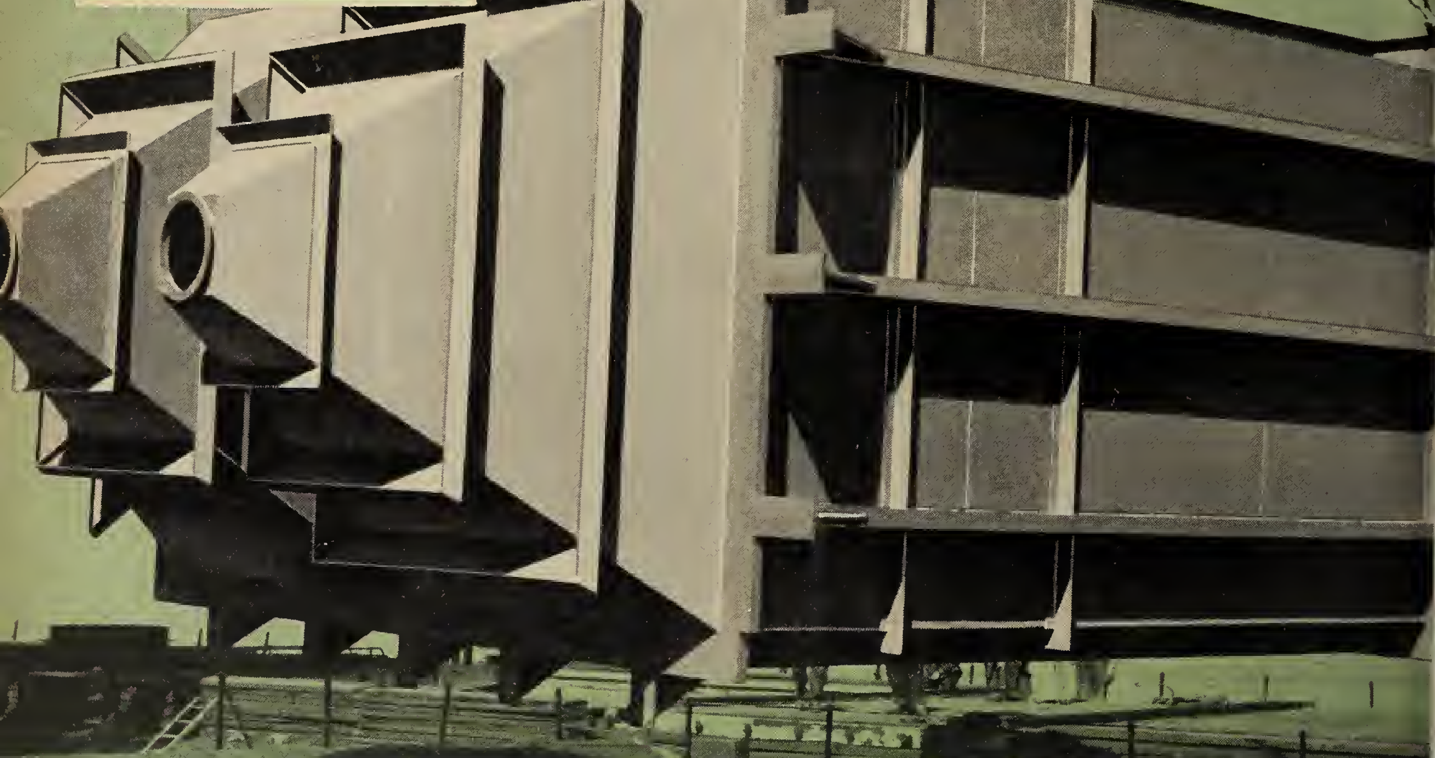
Printed in Toronto

Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, Post Office Department, Ottawa.



Giant camera for Outer Space? No, but...



DAVIESHIP can build any size or shape o engineering structure you may require!

This massive 3-D camera-like object is actually a DOUBLE HOPPER MILL FEED BIN — no more than a routine construction job for DAVIESHIP. The flourishing ENGINEERING DIVISION of the famous Davie Shipyards applies the accumulated experience of a century of shipbuilding to every construction problem. Whether your requirements call for gigantic equipment or small individual parts, we can supply your needs. Just give us a call whenever we can be of service to you.

D DAVIESHIP

BIG 'D' STANDS FOR 'BIG DAVIE'

DAVIE SHIPBUILDING LIMITED, LAUZON, QUE.

SHIP BUILDING · SHIP REPAIRING · PRESSURE VESSELS · PENSTOCKS

GATES · STEEL STRUCTURES · INDUSTRIAL MACHINERY & EQUIPMENT

Meet the Authors

William H. Bender, B.Sc. Civil (Technische Hochschule '50), Project Engineer, Dominion Bridge Company Limited, Winnipeg, Manitoba. *(Design and Erection of Structural Steel for the International Nickel Company's Thompson Project.)*

Mr. Bender came to Canada in 1951 and was with the Bridge and Tank Co. of Winnipeg for two and one-half years before joining Dominion Bridge.

Ernest M. Scott, M.E.I.C., B.Sc. E.E. (Manitoba '46), Assistant Manager, Engineering and Construction Division, The Manitoba Hydro Electric Board, Winnipeg. *(Microwave Radio Application to an Electric Utility Load Despatch System.)*

Upon graduation Mr. Scott joined the Canadian General Electric Company and served on their Test Course. He was Chief, Electrical Section, Engineering and Construction Division of his present organization for three years, and was appointed to the position he now holds in 1959.

Krystyn Z. Lukaszewicz, B.Sc. (London, Eng. '48), Design Engineer, Motor and Generator Department, Canadian General Electric Company, Peterborough, Ontario. *(The Evolution and Application of Large Synchronous and Induction Motors in Canada).*

Mr. Lukaszewicz spent a year of research on H.V. cables and Accessories with B.I.C.C. Ltd. (England). For two years he was with Ferranti Ltd. (England) as a design and research engineer, distribution transformers; he joined his present firm in 1951. He is a member of the Association of Professional Engineers of Ontario, the American Institute of Electrical Engineers and an associate member of the Institution of Electrical Engineers.

K. Z. Lukaszewicz

G. W. Herzog
M.E.I.C.

Gordon W. Herzog, M.E.I.C., B.Sc. (Alberta '46), Design Engineer, Industrial Synchronous Machines, Canadian General Electric Company, Peterborough, Ontario. *(The Evolution and Application of Large Synchronous and Induction Motors in Canada).*

Mr. Herzog has been with C.G.E. since graduation and has had extensive design experience on synchronous, induction and inductor machines. He is a member of the American Institute of Electrical Engineers and the Canadian Standards Association committee on rotating machines.

W. H. Bender

A. Braun

Anton Braun, Vice-President and Technical Director, Free Piston Development Company Ltd., Kingston, Ontario. *(The Potential in the Free Piston Engine Principal).*

After graduation from Rhine Engineering College in Germany, Mr. Braun did turbine and power plant application engineering for three years and came to Canada in 1952, when he joined Dominion Road Machinery Co. He was later on the staff of Queen's University for three years.

Henry A. Spencer, M.E.I.C., B.Sc. Mechanical (Saskatchewan '45), Associate Research Officer, Industrial Engineering Services, Research Council of Alberta, Edmonton. *(Liquid Petroleum Gases as Fuels for Automotive Engines).*

Mr. Spencer worked as engineer, Diesel Division, Dominion Engineering Works Ltd., (Montreal); as designer for Atlas-Imperial Diesel Engine Co. (Oakland, Calif.); as tool designer for Caterpillar Tractor (San Leandro, Calif.); and as research engineer and production engineer for the Friden Calculating Machine Co. (San Leandro). He joined the Research Council of Alberta in 1953.

Kenneth H. Williamson, Jr. E.I.C., B.Sc. E.E. (Manitoba '49), Communications Engineer, Manitoba Hydro Electric Board, Winnipeg. *(Load-Frequency Control System of the Manitoba Hydro-Electric Board.)*

After two years with the Manitoba Telephone System's Transmission Department, Mr. Williamson was awarded an Athlone Fellowship, U.K. development laboratories for radio and carrier equipment, after which he returned to the M.T.S.'s microwave radio division. He was on loan to the Bell Telephone (Montreal) for a year in connection with their Mid-Canada Line work.

COVER ILLUSTRATION

The erection of hoist house steel on top of the headframe at the Thompson Project. A five ton derrick is set up and a three drum engine is hoisted to machine floor level 220 ft. above ground. ***(Photo courtesy of Dominion Bridge Company Limited.)***

where to save refining dollars

WITH

ROCKWELL-Nordstrom **VALVES**

DESIGN AND ERECTION OF STRUCTURAL STEEL FOR THE THOMPSON PROJECT

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

W. H. Bender
Project Engineer,
Dominion Bridge Company Limited,
Winnipeg

Preliminary milling operations are scheduled to get underway next month at Inco's mining development at Thompson, Manitoba. This marks the first operational stage, a bare 3½ years after the initial planning of the project. In December, 1956 the International Nickel Company announced that they were going ahead with the construction of a mining development in the Moak Lake, Mystery Lake area, some 450 miles north of Winnipeg. Details and extent of this project were not disclosed at that time, but there were indications that this development would include a reduction and smelting plant. The construction of a refinery, to make this a fully integrated operation, was announced in March, 1959. A townsite with facilities for a population of 8,000 was to be built close to the plant. The town, named after the Chairman of the Board of International Nickel Company of Canada, "Thompson" is located 30 miles north of the half-way point on the C.N. main line between The Pas and Churchill. There was no access to Thompson by road or rail at that time.

DURING THE winter of 1956-57 work got underway on a large construction camp. In the Spring of 1957, a 30 mile long spur was started into Thompson, branching off the railway line at a little place called Sipiwesk. It was a big event for Thompson when on October 13, 1957 the first train rolled into the town's railway station. Thousands of tons of building materials and supplies have been shipped on this line, which still represents the only connection by land to the rest of the world.

To provide power the Manitoba Hydro Electric Board will harness the turbulent waters of the Grand Rapids on the Nelson River, at a site 50 miles from Thompson.

In late 1956, engineering work on the surface buildings started in Inco's Head Office at Copper Cliff. For the purpose of description, the surface buildings can best be divided into four groups, namely:

(1) Auxiliary Buildings consisting of Shops Buildings, Office Building, Warehouse, Change House, Fire Hall and Compressor Building;
(2) Concentrator and Headframe;
(3) Smelter;
(4) Refinery.

Fig. 1. Camp site at Thompson with Office Building in foreground.

All these buildings are steel structures except for the Headframe, which is of reinforced concrete design. Dominion Bridge Company was the structural steel contractor for all surface buildings, with the exception of a Switching Structure and Cottrell Building. The Auxiliary Buildings are of conventional design and are not expected to be of particular interest to this audience.

Prefabricated panels, tar and gravel are used for the roof construction of all buildings. Exterior walls have sheeting—one flat board on the inside and a corrugated sheet on the outside.

Structural Design in General

The three process buildings, Concentrator, Smelter and Refinery were designed according to Inco's own structural specification, which generally follows the AISC except for allowable stresses. The allowable bending stress is 18,000 p.s.i. with a corrosion allowance of 15% added to all external loads. For simplicity of design and detailing, we converted the 15% corrosive allowance into a further reduction and then worked to 78% of all AISC allowable stresses. Beam connections were made for maximum listed loads. The design snow load was 50 p.s.f., wind 30 p.s.f. and wind on the Hoist House on top of the Headframe, 40 p.s.f. The customer specified field riveted connections except for purlins, girts and handrail which were field bolted. Checkered plate and stair treads were also riveted.

The Three Process Buildings

The Concentrator: The Concentrator is a fairly intricate process building and contains mainly the Crushers, the Ball Mills, the Flotation Cells, Sampling Equipment and Sand and Reagent Storage. There are approximately 20 belt conveyors which transport the ore to the various stations for treatment. A 40 ton Overhead Crane serves the Ball Mills for maintenance. In order to maintain handling of the ore at a minimum, the concentrator is built around the lower portion of the Headframe. Adjacent to the Headframe is a one storey Mine Office and Change House. The main frame of the Concentrator was erected with Crawler Cranes. The high portion over the Fine Ore Bins was beyond the reach of a Crawler, and had to be erected with a Stiffleg Derrick which was set up on a Traveller on top of the Mill Aisle. Erection of the Concentrator steel was completed in November-December, 1958.

To erect the Hoist House steel on top of the Headframe, a Stiffleg Derrick and Hoist were set up at the machine floor, 220 ft. above ground and all steel had to be hoisted to this level before it could be placed. There is a 20 ton Maintenance Crane in the Hoist House to serve the friction type hoist for maintenance. From the top of the Headframe, one gets a very impressive view of the entire project.

The Smelter Building: The Smelter is by far the largest and heaviest building of the project. The dimensions are approximately 500 ft. long by 400 ft. wide by 120 ft. high. There are mainly four floors of 20 ft. storey height and the fifth floor in the Roaster section has a 40 ft. tier. Structural design for the Smelter got underway in May, 1957 and was completed about a year later. Design floor and equipment loads are heavy. All working floors are covered with 5/16 in. checkered plate, reinforced by stiffeners to resist concentrated loads. Concrete floors are used in electrical and pump rooms and around the filters. Floor framing was kept uniform in the main process areas so that a high degree of standardization was afforded throughout.

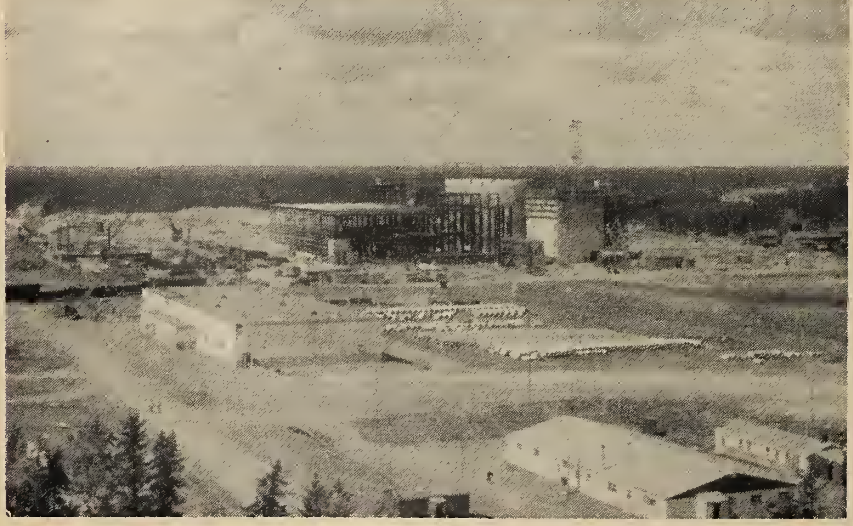
The design of an industrial plant, like the Smelter, must aim to meet the special conditions which arise inevitably from the functions which the building is required to perform. With regard to the structural design, the Smelter Building is by far the most complicated building of the project. The fact that heavy equipment was not purchased until the late design stages, added more difficulty. Many assumptions as to loading and type of framing were made at an early stage of design and as some of the heavier equipment weighs as much as 300 tons, these assumptions had to be reasonably correct or at least on the safe side. In some areas the structural framing is designed and laid out to suit possible future loading conditions arising from changes in process and equipment.

With several engineering groups engaged in the project, co-ordination of their activities became a very important factor. This also entailed advising our Productive Departments of target dates, tonnages, revisions, and cancellations.

During the design of the structure for the Smelter, we were constantly racing against time, trying to keep ahead of the production schedules. Large tonnages of steel had to be released each month for ordering from the mills, and sufficient information made available to our Drawing Offices for the preparation of shop drawings. The latter often became quite difficult as final framing could not be determined in time, pending information on process equipment. In many cases, the main framing was punched for anticipated connections of sub-framing in order to keep field work to a minimum. Although the building is designed for substantial floor loads throughout, there were sufficient significant differences in the column design on account of heavy equipment and contributory areas to warrant 40 different types of columns. All main building columns are spaced on a 22 ft. module and have an excess capacity of 25% at normal stresses. They must be sufficiently robust to withstand the onerous usage to which they are subject throughout their working life. This usage involves not only heavy loadings, but also wear and tear that is severe by comparison to conventional factories and industrial buildings. The hammer type crane columns support the runway for 2 60 Ton Heavy Duty Cranes. Crane runway beams are simply supported and the crane rail is fastened by hook bolts. The direct load on the Crane Columns is over 1,000 kips and sway and wind moments amount to over 1,000 foot kips. The bottom tier up to the crane seat is made of the heaviest 36 in. Wide Flange section as a core and one heavy 21 in. Wide Flange Beam on each flange. The top tier is a plated 21 in. Wide Flange section. The customer favoured the rolled sections on the face of the core over the conventional plate and angle type built up members. The corrosive fumes would have ready access in

Fig. 3. Crawler boom section is used as falsework under cross flue trusses.

Fig. 2. A Stiffleg Derrick on top of the Mill Aisle Roof is erecting the high portion of the Concentrator.



between the contact faces of the various layers of plates and angles. The built up crane column base has a 6 in. slab and is anchored by 4-2½ in. diam. anchor bolts against up lift. Mechanical anchors were used where the rock elevation was too close to the surface to develop the anchor bolts in bond.

Each crane column weighed 20 tons. 2,000 shop rivets had to be driven per column to build up the compound section. All vertical main bracing is made of Wide Flange sections on the weak axis. Corrosion, the desirability of avoiding dirt traps and the ease of maintenance painting were borne in mind when these sections were decided on. There are three lines of balloon flues in the Smelter. The flue side plates are fastened to 8 in. x 8 in. shoe angles, which are not connected to the stringers so that free movement is possible. Also framing into the shoe angle are the side plates of the suspended dust hoppers. The cross flue is carried on 2-80 ft. span bridge type trusses across the crane aisle about 130 ft. above grade. To take the wind forces across the 80 ft. span, lateral trusses in the plane of the flue stringers had to be furnished. Particular attention was paid to the temperature differential between chords of the horizontal trusses. The outer chord is exposed to the atmosphere and if the stringer had been utilized for the inner chord, the temperature differential would have been 500°F. This differential would have resulted in a stress in the diagonals of the horizontal trusses of 40,000 p.s.i. To avoid this, we introduced a separate inner chord along the flue stringers which by virtue of flexible diaphragms, permitted longitudinal movement of stringers without stressing the web members of the horizontal trusses. Stringers are seated on the supporting girders at expansion joints and framed at intermediate girders. These girders are subject to high bending stresses in the YY axis. The flue plates are insulated and covered by a ten gauge casing plate, where exposed to the atmosphere. A high standard of accuracy in detailing and fabrication is essential for this class of plate work, if erection is to proceed smoothly and with maximum speed. Slight errors that could easily be rectified in the shops are magnified at the site and cause disproportionate delays.

The bulk of the Smelter was erected by cranes. In the furnace aisle, lifts were heavy and access was poor. There were approximately 15 plate girders and 24 crane columns to be erected in single lifts at long reaches. The lightest of these members weighed 16 tons. This ruled out the use of cranes. A 15 ton Stiffleg Derrick was set up on a Traveller to erect the entire furnace aisle steel from four positions. To erect the two 60 ton Ladle Cranes three heavy cranes hoisted the girder into place about 70 ft. above ground. Clearances between adjacent framing and lifting at capacity of the crawlers dictated a very accurate synchronized hoisting operation. Furthermore, footings, trenches and other obstructions at floor level restricted us to a small working area. Four converters were also fabricated and erected. The maximum single lift was 68 tons and it was made by two cranes. Erection of the Smelter Building was completed in September, 1959.

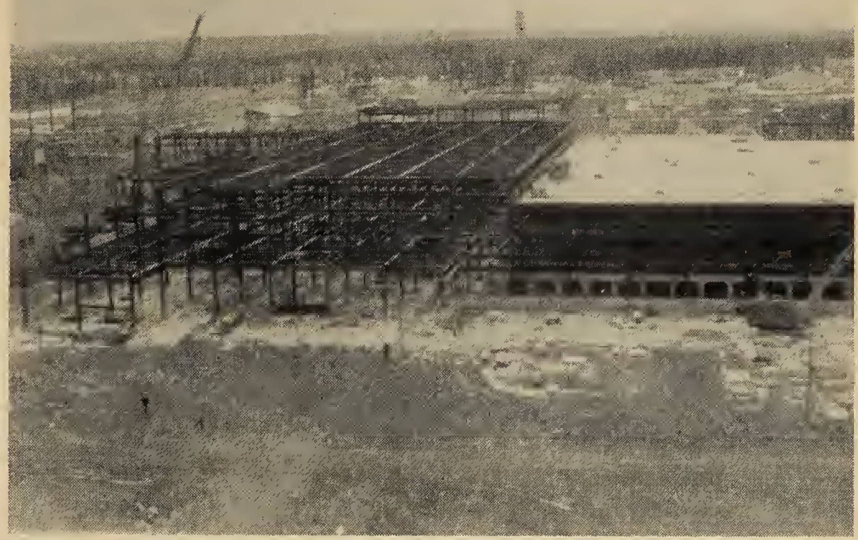


Fig. 4. Erection of Refinery Steel during the fall of 1959.

The Refinery: The second largest building of the project is the Refinery. It is mainly a two storey industrial building, much like a chemical plant. It is 400 ft. wide and approximately 1200 ft. long and houses tanks, containers, vessels and extensive piping. There are numerous runways in the Refinery ranging from 3 ton to 25 ton capacity. Stools and hangers for beam connections are used frequently in this building since there are differences of as much as 4 ft. between girders and stringers in order to clear piping. One noteworthy feature of this building is the fact that there are no windows. Fresh air is supplied by three air conditioning units with large plenum chambers. In one portion, all crane column struts are double plain members to accommodate the duct work for fresh air supply and exhausts. To protect the Refinery structure against severe corrosive fumes, all steel is painted according to Inco's painting specifications. In highly corrosive areas, one shop primer coat was followed by three field coats of anti-corrosive paint. All contact areas with sheeting and roof slabs, as well as areas which are not readily accessible for maintenance painting were coated with a ⅛ in. thick layer of asphalt.

Aspects of Erection

Completion dates for the different stages of the project were set forth by the client. It was a great challenge to meet these dates. Rigid scheduling was required to assure proper flow of material, starting with design and detailing through fabrication and shipping. Extensive planning went into this project so that this large volume of work could be processed through our offices and plants.

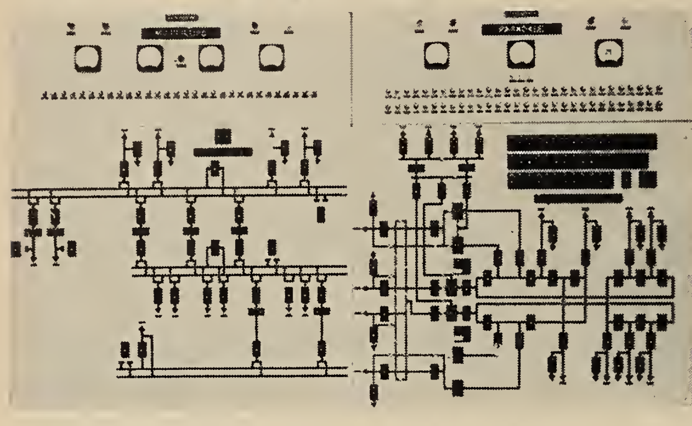
One of the main problems at the site was the providing of man power. It was rather difficult to attract men to stay for an extended period of time in this remote location. When the winter set in, the turn-over increased steadily reaching a peak around Christmas. Sub-zero temperatures as low as 50 below for several days made our operations extremely difficult during the three cold winter months. Despite these difficulties, our crews erected over 1500 tons in January, 1959 and 1700 tons in February, 1959. The record month for erection was April, 1959, when over 3000 tons of steel were erected.

Conclusion and Acknowledgement

Steel work for the Thompson Project is completed. From the start of the design to completion of erection three years have gone by, three very interesting years, crowned by accomplishment.

The author would like to record his appreciation for the guidance, cooperation and encouragement given him by all groups concerned.

MICROWAVE RADIO APPLICATION TO AN ELECTRIC UTILITY LOAD DESPATCH SYSTEM



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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

It is almost inevitable that historical facts are bound to work a considerable influence on virtually any considerations that an electric utility gives to the rehabilitation or extension of any of its facilities. Certainly this can be said of the utility's communication system and proved to be the case when, in 1956, the Manitoba Hydro Electric Board turned its attention to a thorough assessment of its then existent communication facilities and to the task that this system, in an extended or modified form, would be required to perform in the years to come.

HISTORICALLY, voice communication had been the primary requirement and this need had been met largely through the medium of privately owned land lines which had been constructed adjacent to, and on common right-of-way with, high tension lines emanating from hydro electric generating stations on the Winnipeg River and terminating at appropriate terminal stations in the Greater Winnipeg area. These were augmented, particularly within Greater Winnipeg, by leased facilities from the Manitoba Telephone System. Also, in the eastern extremity of the system, a single inductively coupled power line carrier link had been established between the Seven Sisters Generating Station and the town of Kenora in Ontario.

By the 1940's traffic density had increased appreciably and a requirement for voice communication with mobile construction and maintenance forces had developed to the extent that a vhf radio system had been added and integrated with the land line facilities.

Working in conjunction one with the other, the land line and vhf radio network had proven adequate up to the mid-fifties. However, by 1956 it was recognized that not only was the existing communications system becoming over-loaded and inadequate but technological advances in such areas as communication, supervisory control, telemetering, and system load and frequency control, when combined with the need for centralized system despatching methods, called for a complete re-appraisal of the communication facilities. Augmenting these considerations too was the recognition of the fact that the electric system was continuing to expand on the national average of 7% per annum compounded and a "look down the road" to a point 20 or 25 years forward was necessary.

In 1956 The Manitoba Hydro Electric Board system consisted of four hydro electric generating stations located on the Winnipeg River, and comprising a total installed capacity of some 420,000 kw., together with the associated transmission lines and three principal terminal stations in the Greater Winnipeg area. In addition, a number of other system developments were either under construction or contemplated which were destined to work a marked change in the total system communications requirements in the space of less than five years. These included plans for interconnections with the City of Winnipeg Hydro Electric System and with the Northwestern Region of the Ontario Hydro Electric Power Commission together with the recognized need for an interconnection with the Saskatchewan Power Corporation in the not too distant future. As to new generating capacity, construction had already been initiated on a four unit 132 mw. thermal electric generating station at Brandon, Manitoba and a decision was imminent which would lead to the advancement of construction of a two unit 132 mw. thermal electric generating station at Selkirk, Manitoba.

Fundamental to these considerations was the realization that while by 1960 the interconnected generating capacity within the Province of Manitoba itself would amount to some 850 mw. at a total of nine generating stations, the characteristic of system load doubling every ten years indicated that any adequate communications system must at least be such that it could be readily capable of comprehending, or being expanded to comprehend, the total system needs at a point approximately 20 years hence. In other words, it was reasonable to presume that by 1980 the generating capacity of The Southern Manitoba System would be in the order of 3,500 mw. and the communications pattern to be adopted must be such as to be capable of catering to such a system.

Up to 1956 centralized system generation and load despatching had not proven requisite but it was recognized that the transition to a centrally despatched system must be effected. Further, the central despatch office which would be created would require an intimate knowledge of pertinent system conditions on a virtually continuous basis. The needs of this despatch office, as had already become the case on much larger systems, would embody not only voice communications but also telemetering of certain system flow quantities, supervisory control of remotely located terminal stations and hydro electric generating stations, automatic system frequency and tie line control, and subsequently, automatic incremental loading of system generation.

In seeking the ideal scheme to be adopted three basic patterns were open to appraisal, namely: land lines, power line carrier and some form of radio medium.

In looking at an assessment of the possibilities it was, of course, first necessary to stipulate the extent and character of the traffic to be accommodated both in the immediate future and in the extended system which might be expected to develop over the years. Fig. 5 comprehends the "immediate future" condition and shows the stations that required communication media and the type and number of functions required to be carried to or from each point.

In the assessment which followed it became evident that no single medium would be ideal for all requirements. Generally speaking the traffic density in the area between Winnipeg and the Winnipeg River was heavy whereas the traffic anticipated between Winnipeg and the western boundary of the Province (like that which might be expected to develop between Winnipeg and potential hydro electric generating sites on the Saskatchewan, Nelson and Churchill Rivers) was not as dense. Further, the distances involved between the central despatch office which was to be located in the new head office building of The Manitoba Hydro Electric Board in Winnipeg, and the Winnipeg River plants, were relatively short whereas the distances involved to existing or potential installations in the westerly and northerly reaches of the Province were very appreciable. Also of importance to the development of the comparative study was the fact that not only did the frequency spectrum available for application of power line carrier impose relatively restricted limitations on the total traffic which could be handled by this medium but also the transmission and terminal station configuration in the Greater Winnipeg area was such that, if a power line carrier system were to be adopted, costs would be increased by the trapping and by-passing which would be necessary, or alternatively, fairly extensive usage of privately owned or leased land lines would be required in the Greater Winnipeg area in order to convey the intelligence the last several miles to the despatch office. Lastly, the critical nature of the communication application was such that its availability must approach 100% and it must, insofar as possible, be completely beyond the influence of storms, atmospheric disturbances, loss of normal a-c. power supplies, and inadvertent action on the part of maintenance personnel. These several influences tended to rule against any serious consideration of the adoption of land lines except where the economics of application of power line carrier or radio proved unjustified.

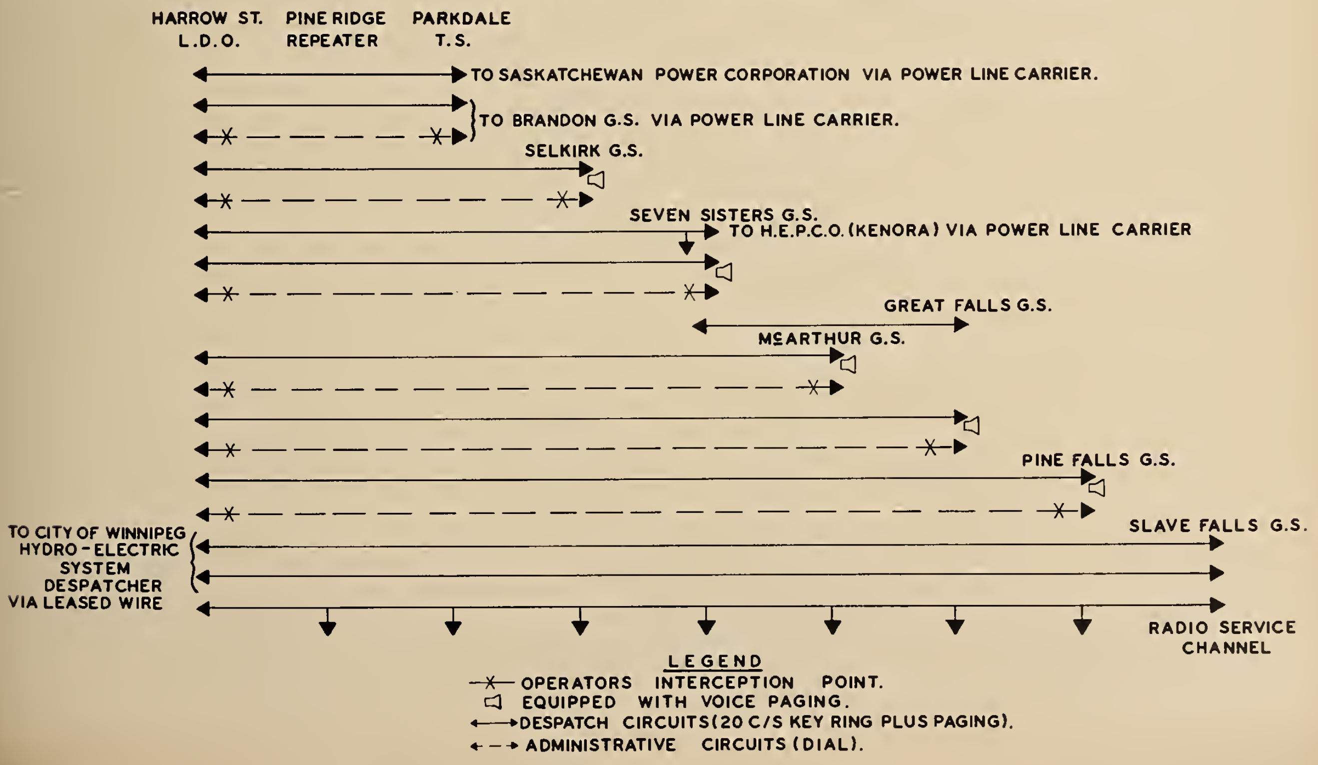
In summary, the development of land lines was ruled out on the basis of both high cost and low reliability. Power line carrier was shown to be the ideal medium for retention and application in those areas where long hauls involving relatively light traffic was required. Microwave radio then proved to be the chosen media for usage where the distances were limited and the intensity of the traffic anticipated to be extreme.

The requirements of both the new thermal electric generating station at Brandon, some 140 miles west of Winnipeg, and the anticipated interconnection with Saskatchewan, involved fairly limited traffic over long distances. As two 115 kv. transmission lines were already in existence between Brandon Generating Station and Parkdale Terminal Station (some 18 miles north of the despatch office) power line carrier was the natural choice. Bringing this information into Harrow Terminal Station, which is located adjacent to the despatch office, directly by power line carrier would have involved extensive by-passing line equipment, i.e. couplers, traps, etc., with additional similar equipment likely to be involved in the future as new planned substations are inserted in the transmission path.

The extension to the despatch office was therefore effected as shown below. On the eastern extremity of the system the requirements of the interconnection with the Northwestern Region of the Ontario Hydro Electric Power Commission System were likewise satisfied by means of power line carrier over the tie line with extension from western terminus of the interconnection at the Seven Sisters Generating Station being accomplished as indicated below.

During the development of the scheme it was also decided jointly by The Manitoba Hydro Electric Board and the City of Winnipeg Hydro Electric System that the latter's hydro electric generating station at Slave Falls should be brought into the radio system to enable voice and telemeter information to be brought into Winnipeg. The City of Winnipeg's generating station at Pointe du Bois on the Winnipeg River was already connected to Slave Falls by telephone pairs and these could likewise be extended to Winnipeg via the radio scheme.

Fig. 1. Microwave radio system — schedule of designated despatch and administrative voice channels.



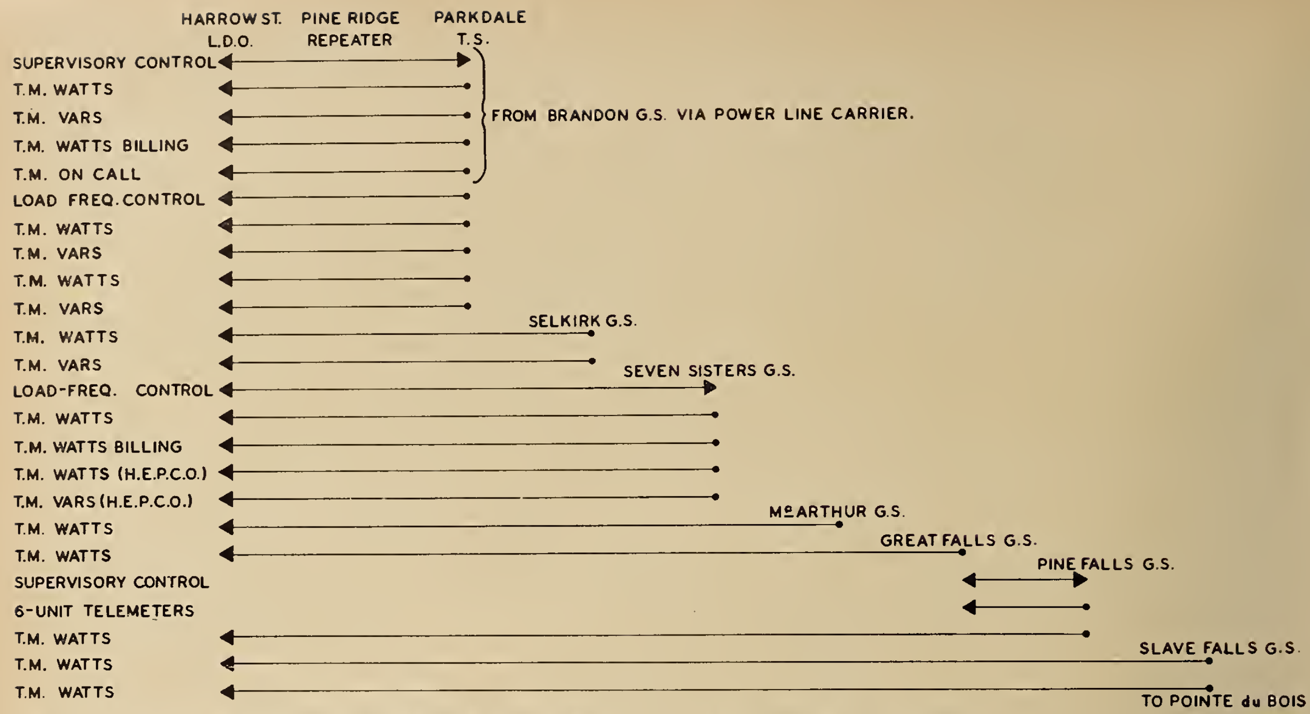


Fig. 2. Schedule of allocated telemetering, supervisory control and load and frequency control narrow band channels.

The results of a detailed field study carried out by the Board were combined with contour information available from Geodetic Survey maps to ascertain the approximate tower heights required for microwave and it was found that by judicious choice of location only one junction repeater point was necessary. Its location on Pine Ridge was such that it could serve the threefold purpose of connecting each of the Parkdale Terminal Station, Selkirk Generating Station and Seven Sisters Generating Station with the Harrow Street despatch office. No one of the three points mentioned could be reached by the despatch office with direct hops while employing realistic antennae heights and adequate line of site clearances. Also the Seven Sisters Generating Station, serving as drop repeater point, proved ideal for relaying to the several other stations on the Winnipeg River.

The decision on policy having been established specifications for a microwave radio system were prepared and the equipment ultimately selected operates in the 2,000 megacycle band. It has a basic capability of 30 voice channels but the specific selection was partially predicated by the fact that with little expense and inconvenience this base band can be expanded to 120 voice channels. In other words the choice of microwave has enabled a broadband path to be established between eight key points and the equipment selected is such as to enable ready expansion on any or all links at very modest cost and without the fear of congested spectrums.

By the use of microwave carrier in the comparatively heavy traffic areas, power line carrier in the lighter long haul areas and leased wire for certain applications in the urban areas, media for the transmission of voice, telemetering and control functions were set up between the load despatch office and all key generating stations and terminal stations on the Board's system. The existing vhf radio and certain of the land lines have not been retired but rather have assumed the new role of providing effective back-up to the new primary modes of communication in addition to the vhf radio's continued important role of coverage to mobile crews engaged in maintenance.

The displacement of the new efficient carriers having been decided upon, it then became necessary to explore their inherent advantages in the most effective and reliable manner to give the despatchers a complete and continuous picture of the system in order that they might exercise intelligent and precise control with a maximum of speed, accuracy and reliability.

Voice Channels

To achieve optimum utilization of the radio baseband together with good signal-to-noise characteristics, single sideband suppressed carrier voice channels in the frequency division multiplex pattern were employed. It was decided that the system should cater for two basic classes of voice traffic namely, despatch and administrative. Further, both of these classifications were established in a radial or spoke-like pattern with the head office building as a hub. It will be realized that this highly desirable radial system with no intermediate stations involving switching equipment is most readily obtainable on a wideband system such as microwave.

One end of each of the despatch circuits terminates at the duplex switchboards of the load despatcher while the other end terminates in the control rooms of the various generating stations and terminal stations. The work of the load despatch office and station personnel is further facilitated by the provision of amplifiers and loudspeakers in the generating station control rooms. The despatcher has merely to depress the appropriate circuit key and commence speaking. He is immediately heard over the loudspeaker in the selected generating station control room. The operator in the generating station control room will thus directly receive instructions with a minimum of time consumption. Should discussion with the system load despatcher be required the station operator has merely to pick up a telephone instrument. In doing so the loudspeaker is cut off and the conversation continues via the telephone sets. Conventional key ringing is available to augment the above process. Also, by simultaneously depressing a number of keys, the despatcher is able to be heard in the several selected control rooms simultaneously thereby saving considerable time and effort. Similarly party line discussions with several station operators can be quickly established.

Of lower priority but nonetheless essential, the administrative circuits provide a rapid and convenient facility over which company business may pass. Each generating station is provided with a private automatic exchange (PAX) to serve the requirements of the power house and the company phones in the townsite. These administrative circuits on the microwave system serve as trunks between the PAX's at the generating stations and the Board's central offices in Winnipeg. Equivalent administrative circuits are provided to terminal station points as required and dial facilities are incorporated so that all the administrative phones throughout the total system assume an equivalent status of being locals to the private branch exchange (PBX) in the Board's head office building. The fact that the administrative channels have been established on a radial pattern equivalent to the despatch circuits results in their ability to perform the alternate function of providing standby in case of despatch channel failure. The despatchers have priority access keys on their switchboards which are at their disposal to cater for this eventuality.

For their convenience the despatchers also have the vhf and company owned land lines terminated on their switchboard. Leased wire lines to important terminal and substations as well as both leased wire lines and vhf radio links to the load despatchers of the City of Winnipeg Hydro Electric System and the Manitoba Power Commission complete The Manitoba Hydro-Electric Board load despatchers complement. Through the medium of power line carrier facilities either installed or being installed in each of the neighbouring provinces, the Winnipeg load despatcher will also be able to speak directly with his opposite number in Ontario at Port Arthur and in Saskatchewan at either Saskatoon or Regina.

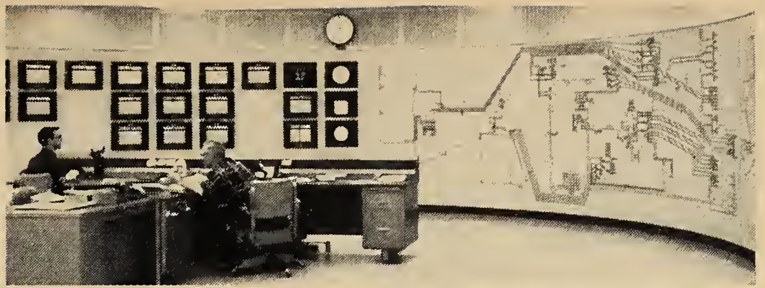


Fig. 3. Harrow Street central load despatch office indicating system mimic diagram, continuous recording equipment, operators' desk and telephone switchboard facilities.

Telemeter and Control Channels

The telemeter and control channel schedule is shown in Fig. 2. Generating station totalized output watt and var quantities together with equivalent quantities from tie lines and certain other selected transmission lines are displayed in the load despatch office together with system key voltages and system frequency on high speed strip chart recorders. The watt and var quantities are converted at the point of origin from currents and potentials by means of one second thermal converters into proportional millivolts. The thermal converter outputs are fed into high speed frequency type telemeters which sine wave modulate (thereby eliminating relays and keys) amplitude-modulated tones on the microwave system and frequency shift equipment on the power line carrier. The reverse or demodulating process takes place at the despatch office channel equipment thereby providing the necessary millivolt input for the recorders.

Fig. 4. M.H.E.B. load despatch office telephone duplex switchboards.

Because of the comparatively quiet medium of microwave carrier with the constant level qualities of frequency modulation, straight forward amplitude-modulated tones were selected for carrying telemeter and control functions. On the inherently noisier or more susceptible-to-noise background of power line carrier, noise immune frequency-shift equipment was selected for these services. The experience to date is such that the record encourages belief that these selections were not incorrect.

Resulting from a program which is current at the present time there will shortly be some ten terminal stations and substations operated by supervisory control from the load despatch office. As this program is extended it is anticipated that each of microwave carrier, power line carrier and leased land line will contribute toward providing the tone channels.

The system tie line load and frequency control installation is also focused on the central load despatch office. As previously indicated watt and var quantities from the tie lines of each of Ontario and Saskatchewan are telemetered to the load despatch office and intelligence is transmitted from the load despatch office to the Seven Sisters Generating Station for the purpose of automatic control of the output of six water wheel turbine alternators at this location. The details of this load and frequency control system are developed in a companion paper but it is perhaps significant to draw attention to the critical, continuous nature of the function which is being served and to the fact that, as in the case of certain of the voice channels referred to previously, the tone channels associated with this system are required to be extended to or work together with associated equipment in Ontario and, in the near future, in Saskatchewan also.

Safety Margins and Standby Equipment

As already stated the assurance of continuity in each of the several services embodied in this communications system is of the utmost importance and has received considerable attention resulting in the specification of suitable safety margins and standby equipment.

Fade margins based on statistical data have been incorporated into all paths of the microwave system so as to ensure propagation reliability during abnormal atmospheric conditions. Duplicate cold standby equipment is provided at all stations of the microwave system so as to be available in the event of failure of the main equipment. Changeover to cold standby is, of course, automatic.

Where a telemeter or control function is considered to be of the utmost priority, the channel has been duplicated as have the power supplies which are involved. In addition, these selected functions are inserted directly into the radio baseband and are not sub-multiplexed on voice channels thereby avoiding an unnecessary link in the chain. Channels in this category include those required for load and frequency control and for supervisory control.

At points such as the Pine Ridge radio repeater a diesel generator has been installed in order to afford an emergency power supply. At this particular point and since it is an unattended station, a control channel has been provided to the load despatch office to enable periodic check runs on the diesel generator unit to be carried out. The fact that the unit has started or has failed to start at any time is annunciated in the load despatch office by means of microwave fault recording equipment. The installation of engine generator supplies will shortly be affected at all other points throughout the microwave system so as to make it completely independent in the case of failure of normal a-c. power supplies.

Conclusion

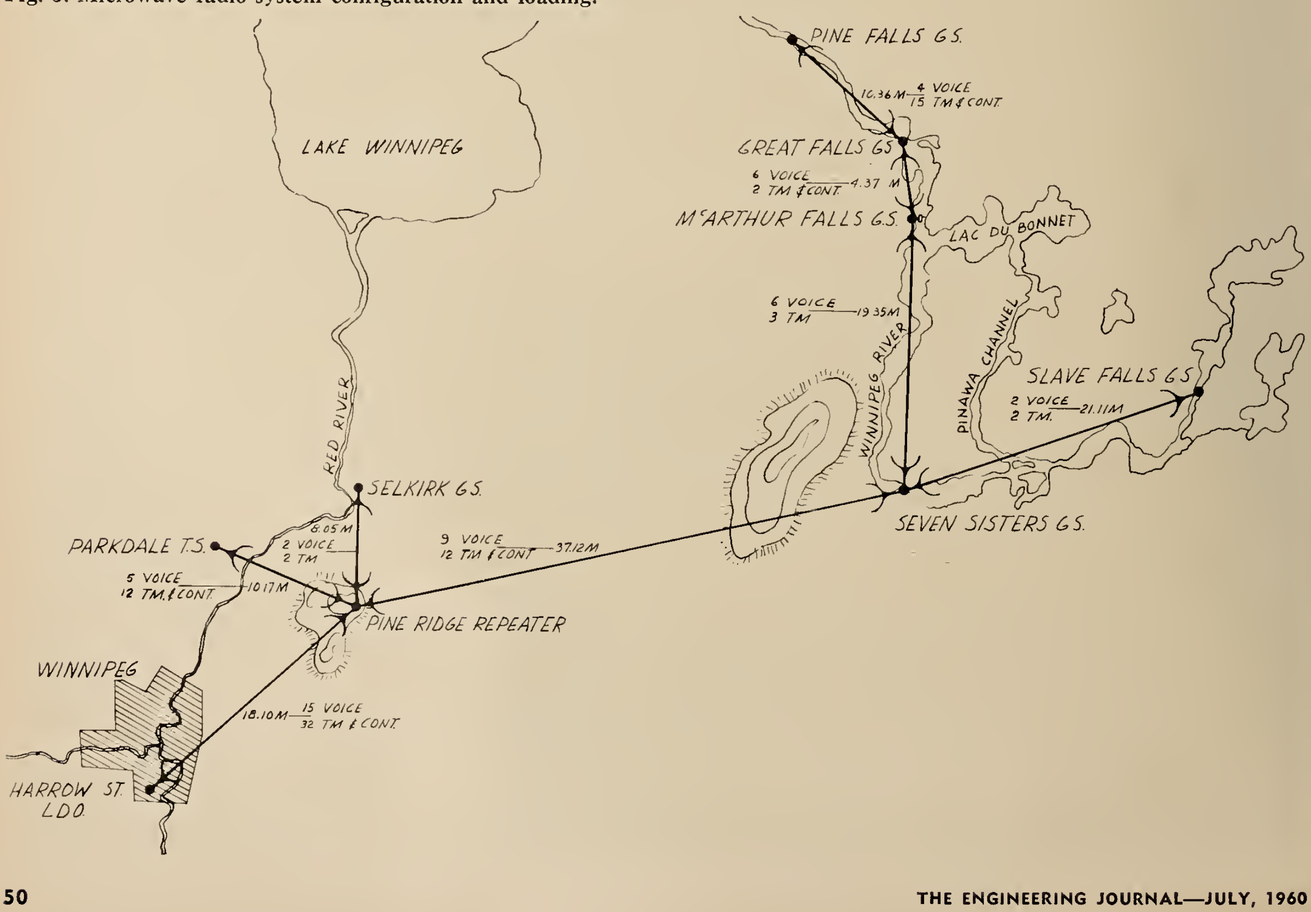
It must be recognized that the microwave is a complex facility which requires an appropriate standard of preventative maintenance. However, attention was given to on-the-job training of the personnel who have subsequently been required to effect the required maintenance and this same body of personnel was utilized to the greatest possible extent in the installation of the original system.

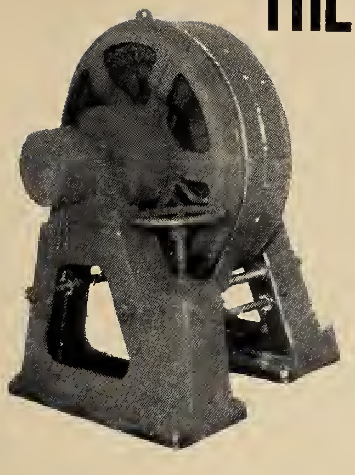
While the operating experience to date has not been without incident and teething problems still appear (the system was first placed in operation in mid 1959) it is believed that the selection of microwave for application to the heavy traffic density requirements of The Manitoba Hydro Electric Board's Southern Manitoba System has been ideal from the standpoint of economy, reliability, flexibility and overall adequacy.

In equipping itself with a microwave system as the backbone of its communications network The Manitoba Hydro-Electric Board has largely eliminated the problem of detailed forecasting of traffic growth in individual areas. Like its contemporaries in medium size but rapidly expanding power systems, it is believed that the adoption of a "wideband" communication media is required and is wholly justified if not absolutely mandatory in providing the flexibility in communications system planning which is needed. Even in the short space of time which has transpired since the original definition of the total refurbished system, developments have taken place the exact nature of which could not be forseen. However, it has been found that the composite system adopted can be readily and conveniently extended to cater for these new requirements.

From the operator's point of view the system is proving to be approaching the ideal and, assuming confidence in the reliability and performance of the system continues to grow as at present, there should be no cause for undue reluctance or concern when expanded application sees the incorporation of fully automated incremental generation control. Carrier type relay schemes for transmission line protection are already being introduced over links in the power line carrier area of the network and it is anticipated that similar protective relay schemes will before long be employed in the microwave system.

Fig. 5. Microwave radio system configuration and loading.





THE EVOLUTION AND APPLICATION OF LARGE SYNCHRONOUS AND INDUCTION MOTORS IN CANADA

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Canada's great industrial expansion over the last 60 years and its present high standard of living are interleaved with the extensive utilization of electrical energy. Canada's per capita consumption of electricity, the second highest in the world, which had risen to the value of 5.0 mwh. per capita per annum in 1955, is a tribute to this country's engineering profession. Applications involving large motors are often very interesting and impressive to watch; for example, a 1500 hp. chipper will cut a 30 in. diam., 30 ft. long log in 3/4 in. chips in 30 sec. Large dredges, steel mills, mine hoists and other applications are equally fascinating. The use, characteristics, and construction of synchronous and induction motors has changed from earlier times. This paper presents some of this record as well as describing application considerations, and one manufacturer's modern construction of large synchronous and induction motors.*

FOLLOWING Dr. Nikola Tesla's prodigious inventions of the polyphase AC system and the induction motor in 1888 the manufacture of alternating-current motors in Canada started in the 1890's. Application of both induction and synchronous motors grew as the industrial expansion took place. At first the use of synchronous and squirrel cage induction motors was limited because of the difficulty of developing sufficient starting torque with reasonably low inrush current. Compressors, pumps, motor generator sets were typical low torque applications. For drives such as ball and rod mills where high torques were required during starting the super synchronous motor filled the need for a time. These motors were constructed so that the stator was free to rotate during starting and synchronization, then braked to standstill while the rotor was accelerated to rated speed. The low starting torque was adequate to accelerate the stator. After synchronization high torque, up to the pull-out value, was available to accelerate the load. Super synchronous motors were built in the range of 150 to 600 hp. at speeds of 180 to 300 rpm. However, they were expensive because they required mechanical brakes for the stator, three extra collector rings with brushes for the high voltage stator winding, an additional set of bearings, and presented a problem of supporting the stator winding against centrifugal forces during starting.

Synchronous induction motors and synchronous motors with phase wound amortisseurs used principally to get lower inrushes have not been applied in Canada to any extent because of their high cost and lower efficiency, and because in general Canadian power systems could accommodate higher inrushes than could the European systems for which these motors were primarily designed.

By 1930 the theory of design of synchronous motors was sufficiently far advanced, principally by engineers in the United States, to permit developing of high starting torques with much lower inrush than was possible before. Furthermore, with the growth of power systems, higher inrush values could be tolerated. With these developments the super synchronous motors lost favour. Since then rapid expansion of synchronous motor applications took place, and now about 90% of the large AC motors over say 500 hp., which are built in Canada are synchronous, the remainder being wound rotor and squirrel cage induction.

*Canada Year Book, 1957-58

Characteristics

The fundamental difference between a synchronous and an induction motor is that the synchronous motor's excitation is direct current and is applied to the rotor whereas the induction motor obtains its excitation from the stator. Differences in construction, operating characteristics, and application evolve from this.

Usually, other considerations than the requirement for constant speed determine whether a synchronous or an induction motor is used.

Synchronous motors have the following advantages:

1. Ability to carry load at 1.0 pf.;
2. Ability to supply reactive kva. for pf. correction and for system voltage regulation;
3. High efficiency;
4. In general — have lower inrush current than squirrel cage induction motors;
5. Pull-out torque is proportional to supply voltage, as compared to breakdown torque in induction motors which varies as voltage squared.

Unity pf. motors are selected when reactive kva. is not required and the pull-out torque of 150% is adequate.

0.8 pf. machines, in addition to their advantage of being able to provide pf. correction as shown in Fig. 2, have higher pull-out torque, usually from 200% to 250% or more. They are physically larger than 1.0 pf. machines, therefore they are more expensive and their efficiency is slightly lower.

Efficiency of synchronous motors is higher than of any other type of motor of the same hp. and speed. Efficiencies of 93-95% are common

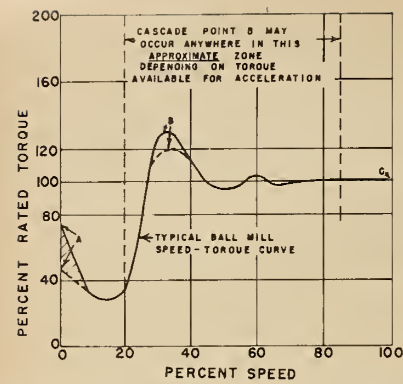


Fig. 1 Typical Ball Mill Speed-Torque Curve

for motors over 1000 hp., and increase with hp. rating.

Lower inrush values for synchronous motors compared to those for squirrel cage induction motors occur because the starting characteristics are more separable from full speed operation.

The advantages of large squirrel cage motors are:

1. Simplicity of starting equipment;
2. Their speed is practically constant, slips of only 1 to 2% at full load are normal;
3. Power factor is quite high and increases with hp. and r.p.m. rating. Values of 85%-90% are common for motors over 500 r.p.m.;
4. They have no collectors to spark, which may make them preferable for some hazardous locations;
5. Their efficiencies are only slightly lower than those of synchronous motors.

Large wound motors have slip, efficiency and power factor practically the same as squirrel cage motors. Their chief advantages are:

1. High torque per amp. during starting. 100% torque throughout acceleration with approximately 100% current, or 200% torque with 200% current is normal;
2. Ability to accelerate very large inertia;
3. Ability to start frequently and stop without overheating;
4. Kinetic energy of the connected inertia can be utilized by the use of a slip regulator to reduce the peak hp. rating and to maintain fairly constant current despite widely fluctuating loads.

However, wound rotor motors are more expensive than the other two types.

Application Considerations

Large motors are individually designed to meet the specifications. The most economical and successful combination of the AC motor and the driven unit is only possible if the characteristics of the motor and the driven load are properly matched. Close cooperation and exchange of applicable technical information between the driven equipment manufacturer, the motor designer, and the user is essential.

For these motors it is as important to match the starting characteristics of the load requirements as it is to have the rated load conditions matched.

An AC motor must be properly specified so that there is no misunderstanding between the one who specifies the rating and the motor design engineer. The use of CEMA, ASA, and AIEE Standards assists in the problem of communication.

The rating must be such that the motor can accelerate its load to rated speed within inrush limitations if any; drive the load within its kva. or hp. rating; carry the peak torque overload; limit current pulsations, where applicable, to agreed values; operate with the expected voltage variations, and be suitable for the expected service conditions of ambient, altitude, air contamination and other special requirements. Some aspects of rating are given below.

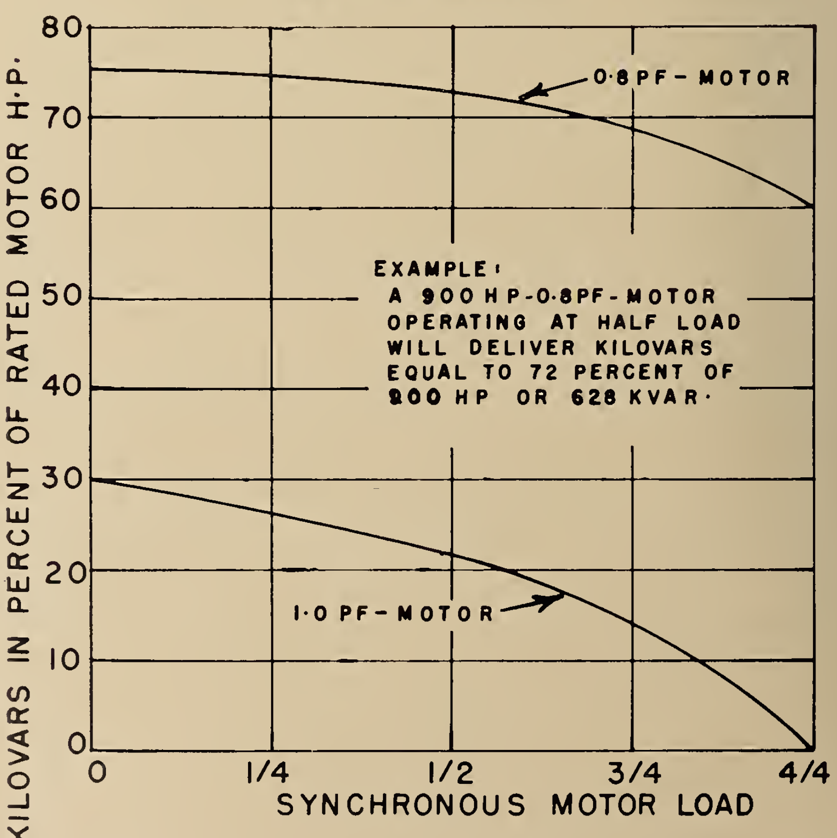
The selection of hp. rating for steady loads requires no comment but for pulsating or fluctuating loads the rating should be established from r.m.s. kva. because power factor may vary considerably for synchronous and induction motors for such conditions. The r.m.s. kva. will always be larger than the corresponding r.m.s. hp.

Whether a motor can successfully accelerate its load to full speed depends upon four things: Inherent torque characteristics of the motor; load torque from zero to synchronous speed; load inertia; voltage value at the motor terminals during starting.

The motor torque must be greater than the load torque at all speeds. The difference between the motor and the load torque is absorbed in accelerating the motor and load inertias. The smaller the difference between these two torques the greater is the accelerating time and the greater is the motor rotor and stator heating. The load torque near synchronous speed must be known to establish the pull-in requirements for a synchronous motor. For all applications then, and particularly for large hp. ratings, knowledge of the load torque is essential to establish the motor design. Where the exact load torque curve with respect to speed is not available an approximate one is better than nothing.

The load inertia must also be known. For a pure inertia load, i.e., a load with a negligible amount of torque during starting, the amount of energy loss in the rotor circuit, which is developed during accelera-

Fig. 2 Typical reactive kva



tion period, is approximately equal to the increase in kinetic energy of the load inertia. Since acceleration times are relatively short, usually less than 20 sec., most of this loss is stored in the rotor circuit. It is therefore essential in squirrel cage induction and in synchronous motors to provide adequate material in the cage and pole face windings to avoid trouble from overheating. It is evident that the amount of load inertia can affect substantially the size, cost and performance of these motors. If in addition to inertia there is a load torque to overcome during starting the amount of heat to be stored is further increased.

For synchronous motors load inertia and load speed-torque curve must also be known before pull-in torque can be determined. This torque is defined as the maximum constant torque under which the motor will pull its connected inertia load into synchronism at rated voltage and frequency when rated field excitation is applied. The speed to which a motor will bring its connected load depends upon the power required. Whether the motor can pull the load into step from this speed depends upon the inertia of the revolving parts. For a given design the maximum slip from which the motor can synchronize varies as one divided by the square root of the motor and load inertia. It is usual to convert load inertia to an equivalent value at the motor r.p.m.

When specifying the locked rotor and pull-in torque requirements adequate margins must be allowed for variation of motor torque due to the expected change in voltage. A motor that cannot accelerate its load is completely useless. However, excessive margins are also undesirable as they may increase the cost of the motor, may increase inrush current and affect other characteristics adversely.

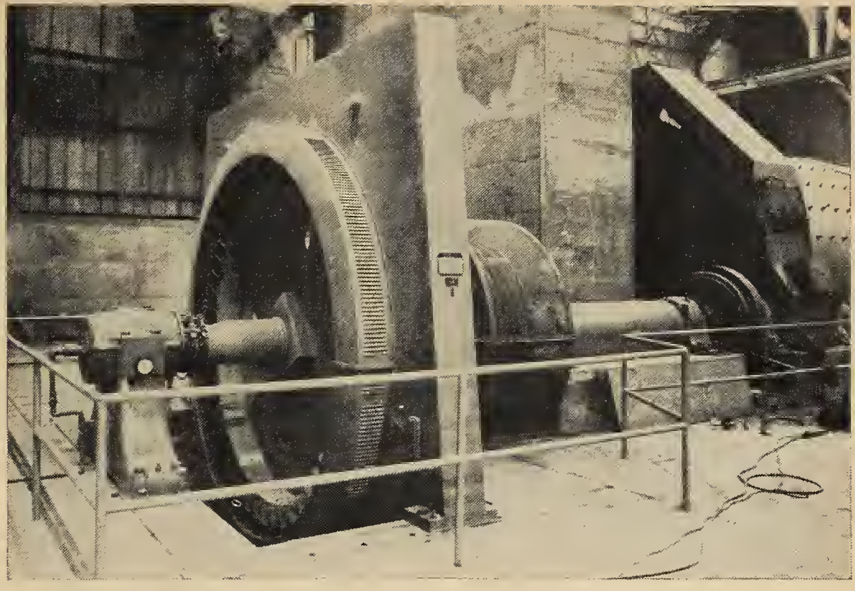
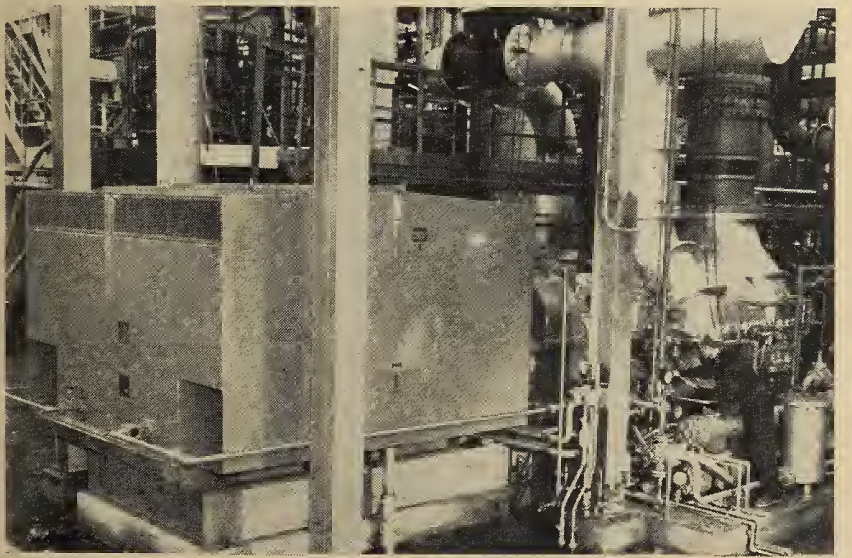


Fig. 3. Synchronous Ball Mill Motors 2500 h.p.—48 Pole—150 r.p.m.—4000 Volts

When applying synchronous motors to pulsating loads, such as reciprocating compressors, it is essential to match the motor design with the load to avoid trouble from torsional vibration and to limit the amount of line current pulsation. The responsibility for this is normally taken by the driven equipment manufacturer.

The usual approach to torsional vibration is to consider the effect of excitation from the load torque variations which is the most important. However, there are other sources of excitation such as: unbalanced line voltage which gives an excitation at twice line frequency; unbalanced secondary resistance of wound rotor induction motors which gives an excitation at two times slip frequency; and a pulsating component of accelerating torque during the starting period of synchronous motors which is at twice slip frequency.

Fig. 4. 3600 h.p.—1190 r.p.m.—4000 Volt squirrel cage weather protected induction motor driving a centrifugal compressor



Typical Applications

The requirements for synchronous and induction motors have grown with Canada's industrial expansion both in the quantity of motors and also in their unit sizes. Pulpwood grinder motors 30 years ago had maximum ratings around 2800 hp., now ratings of 5500-6000 hp. are common. Ball mill motors a few years ago were normally rated 600-800 hp., now ratings of 1500 hp. are common and even 2500 hp. motors have been supplied. 7000 hp. MG set motors (with much larger ones considered), 10,000 hp. dredge motors, 6000 hp. reciprocating compressor motors, 10,000 hp. centrifugal blower motors are further examples of the trend to larger ratings. Photographs of some of these installations are included in Fig. 3 to 7.

It may be of interest to list some of the most common applications for large AC motors.

Synchronous motors are used for various types of compressors, fans, blowers, pulp grinders, chippers, jordans, pumps, rolling mills, rubber mills, ball and rod mills, motor-generator sets and less frequently for other applications.

Wound rotor induction motors are used for mine hoists, motor and generator sets usually with a large flywheel, chippers, dredges, ball and rod mills. Wound rotor motors have

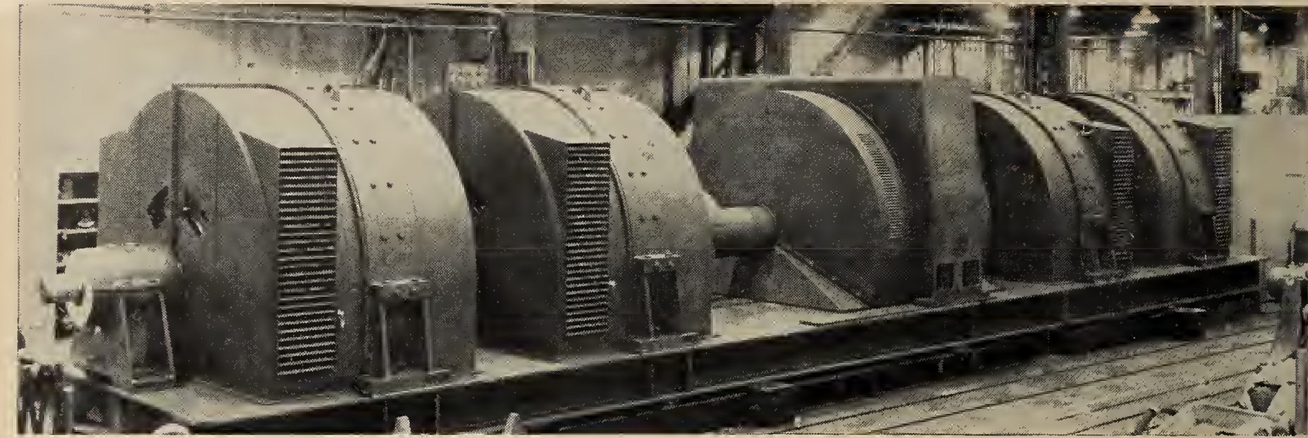


Fig. 5. A 5 unit motor generator set for a steel mill driven by a 7000 h.p.—1.0 P.F.—13,200 Volt—514 r.p.m.

been applied to a large number of mine hoists in Canada. These motors are suitable for manual, semi-automatic or fully automatic operation. Dynamic braking which can be applied reduces the duty of mechanical brakes.

Squirrel cage induction motors are used for vertical and horizontal pumps, high speed centrifugal compressors, fans, jordans, pulverizers, rod and ball mills.

Although it is beyond the scope of this paper to describe in detail many of the applications, a description of a ball mill is included because it exhibits many of the facets of a typical application for synchronous motors.

Ball and rod mills are used for grinding various materials such as ore and cement. A ball mill installation is shown in Fig. 3. During grinding the mills are continuously rotated about a more or less horizontal axis. During rotation the action within the mill consists of continuously lifting portions of the composite materials within the mill until the lifted material falls or tumbles down. The combined actions of impact of falling material especially of the heavy balls and rods (usually of steel) and sliding and tumbling within the mill effectively reduces the particle size. Typical mill speeds are around 20 r.p.m. with the motor speed of 100 to 250 for motors direct connected to a spur gear and 720 to 900 for motors connected to a speed reducer. Typical horsepower ranges are from 200 to 1500, although some larger horsepower ratings have been built; up to 2500 hp.

Fig. 1 shows how the torque required by a typical ball mill varies from breakaway to full speed. The charge is lifted up as a solid mass until at some angle the charge begins to break up or cascade. The maximum torque occurs just before the mill cascades and a good deal of experience has been accumulated to show that the cascade torque is between 100 and 130% of the normal running torque, although certain mill builders feel that the torque may go as high as 140% on occasions. Motor torques normally supplied are 150% locked rotor, 110% pull-in and 150% pull-out for cement mills and 175-110-175 for ore mills. Higher values may be specified to compensate for reduced supply voltage during starting. Pull-in torque requirements are usually based on a load inertia of 3 to 4 times normal at the motor shaft. Normal torques and inertias for other applications are shown in ASA Standards. Occasionally some installations employ standard low torque synchronous motors with a magnetic clutch between the motor and the mill.

Full voltage, full winding starting is the most economical and reliable method of starting large AC motors. This method is now widely used for ball mills. Reactors and saturable reactors placed in series with the stator winding have been used in some cases to reduce the initial shock to the gears.

Approximately once a month it is necessary to position the mill accurately to add fresh balls. This is normally done by running the motor up to speed and pushing the stop button as a certain point on the outer rim passes a mark. Alternatively, specially designed spotting equipment giving a very low speed of rotation can be supplied.

The atmosphere around the mills is usually very dusty. Motors with open construction should have insulation which resists abrasive wear. Other mills are constructed with the motors located in a separate room.

Construction

Construction of synchronous and induction motors has changed from earlier times reflecting changes which have occurred in requirements, service conditions, improvements and refinements in design, and improvements of materials and manufacturing processes. Modern motors are constructed to be mechanically safe, reliable, relatively easy to service and to provide a greater degree of mechanical protection to the windings.

Early machines were built with cast iron stator frames and rotor spiders. Fig. 6 is representative of this construction. Introduction of welded construction about 1924 opened up new possibilities for the application and design of larger motors. The engineer no longer had to choose between designing to fit an oversize casting pattern with the resulting extra cost and weight in the redundant material or having to order an expensive pattern which might have limited future use. In smaller machines, which are made in reasonably large quantities, greater standardization of parts is possible, hence casting construction is still used for bearing brackets, stator frames and some rotor spiders. In large machines, however, modern practice is to use welded construction exclusively with the exception of some smaller standard components such as bearing shells and pedestals.

Great improvements have been made in insulation systems during recent years. The earliest 105C (Class A) insulations used air as the insulator with cotton and other materials as spacers. Later systems, such as varnished cambric, used tape to support the varnish insulating film. Recently film insulations have been developed which support themselves and have superior physical and dielectric strength.

In 130C (Class B) systems for formed coils, asphalt impregnated flake mica tape is used extensively with some of the newer materials such as reconstructed mica are being used for some of the lower voltages.

Sealed insulation systems are now available in both 105C and 130C classes. These systems have the insulation bonded and sealed between layers to resist the penetration of fine dusts and moisture. Overvoltage factory tests are conducted with the coils immersed in water. Supported and vulcanized silicone rubber tapes are employed in the 130C system.

Synchronous machine wire wound rotor coils have been improved in physical strength, reliability, reduced hot spot, and in sealing by the use of the epoxy resin impregnants. 100% solids epoxy resins which have recently become available exhibit temperature and physical characteristics much superior to previously available materials.

Other details of construction have changed considerably and are too numerous to be listed. Improvements in the design of the ventilation are worth mentioning as they resulted in reduction of the hot spot temperature differentials, greater reliability and substantial reduction in size and weight. Rotors of both synchronous and induction motors have been changed to make them more efficient in blowing the ventilating air. Axial flow propeller fans have been employed on some large high speed units. Top exhaust from the stator is used extensively in open machines to minimize recirculation of the hot air.

The freedom of shape, which is possible with the welded construction, permits the design of various types of motor enclosures which may be required, within reasonable cost. Most motors are built with open or open-dripproof construction which are the cheapest and are applicable to indoor conditions where ambient air is sufficiently clean and dry. The ventilating air is taken directly from the room in which the motors are installed and is usually discharged back into the same room. Adequate ventilation of the room must of course be provided to keep the ambient temperature within permissible limits, usually less than 40°C.

Contamination of the ventilating air is a real problem both for the motor designer and the user. The degree of contamination and its effects varies for different industries. In pulp and paper and chemical industries there may be high humidity, acids or alkalis in the atmosphere which can attack the insulation or cause excessive rusting of internal components. In the cement and mining industries there may be a considerable amount of dust which is likely to be quite abrasive and may also be magnetic. In rubber mills carbon black and other compounds may be present in large quantities which may penetrate the winding insulation or clog the ventilating ducts. There are many other contaminants not mentioned here.

The most common solution is to specify totally enclosed pipe or pit ventilated motors. Clean air is brought into the motor enclosure for bracket bearing machines or into the motor pit for pedestal bearing machines. The exhaust can be, as in open machines, into the motor room or out through the ducts. The external ducts may be quite large and usually a separate blower is required. Normal practice is that the motor is not expected to overcome any external duct pressure drop either at the intake or exhaust.

Fig. 7. 8000 h.p.—257 r.p.m.—13,200 Volts wound rotor induction motor

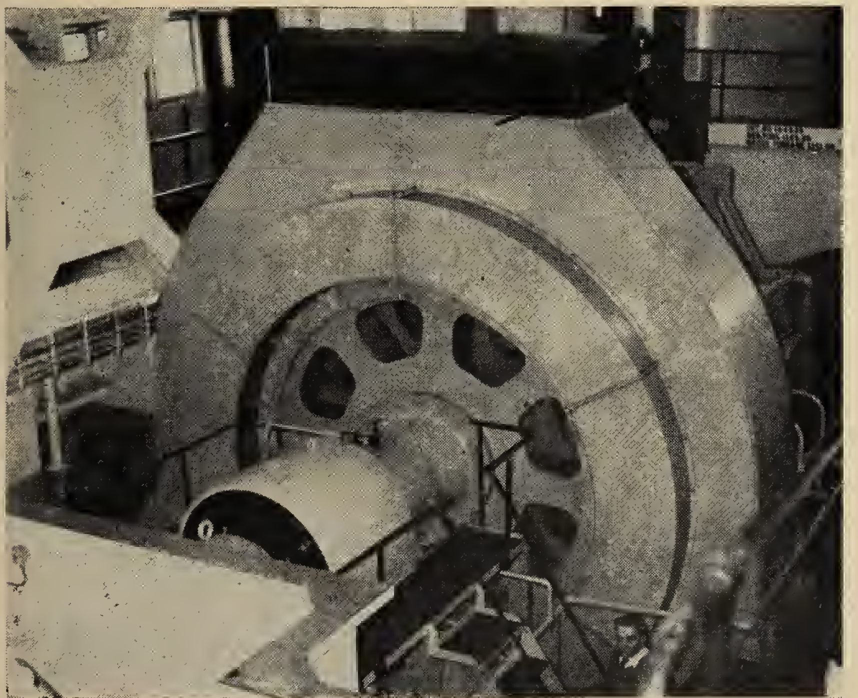


Fig. 6 Synchronous motor built in 1922 to drive a reciprocating compressor

Occasionally totally enclosed water-to-air or totally enclosed fan cooled or air-to-air cooled machines are specified for some applications. The air inside the motor is continuously recirculated which minimizes the need of cleaning the ventilating passages. However, it is necessary to clean the cooler on the water side or on the external air side but this is relatively easy. The air-to-water heat exchanger may be mounted within the motor enclosure, usually above the stator core for easy access, or below the stator core in the motor pit. In the latter case the stator frame is designed to discharge air downwards, through the cooler into the pit and thence back into the rotor. The extra cost of the motors with coolers and cost of cooling water should be compared with the cost of external ducts and blowers, which would be required for pipe or pit ventilated motors.

Locations classified as hazardous by the Canadian Electrical Code because of the presence or the potential presence of flammable gases or vapours or combustible dusts require special construction. Explosion proof and dust-ignition-proof motors are available for some locations in smaller sizes, up to approximately 48″ outside diameter. Their appearance is somewhat similar to totally enclosed fan cooled motors but the construction details are special to meet the requirements defined by the Underwriters' Laboratories. It is impractical to make explosion proof motors in large sizes. Totally enclosed air-to-water cooled motors filled with inert gas, usually nitrogen, under pressure somewhat greater than the atmospheric have been supplied occasionally. The amount of protection against fire or explosion provided depends on the risk involved. Many motors have just the collector rings enclosed and purged with clean air. Forced ventilated motors have also been used. Motor mounted accessories such as relays or space heaters should be designed to minimize the hazard.

Within the last 10 years or so large motors have been built for outdoor operation in weather-protected enclosures. The latest trend is to apply open-dripproof motors outdoors taking advantage of the improved insulation systems. However, when doing so it should be remembered that whilst the insulation may be adequate against moisture, other parts are subject to rusting and dirt can clog the ventilating ducts.

The introduction of sealed insulation systems in the last few years has made it possible to select motors which have a lower degree of enclosure than had been possible in the past. Specific application recommendations are available from the manufacturers.

Design

The electrical, magnetic, thermal and ventilation circuits and the mechanical stresses which exist in A.C. machines are all interrelated so that a change in one usually affects the others. The number and complexity of relationships between the variables makes the design of a rotating machine essentially a "cut and try" process. The dimensions, materials, and type of construction are chosen, then the performance is calculated. The calculated performance is compared to the requirements and if the design objectives are not met the design is altered and the calculations repeated. The rate of convergence depends upon the skill of the designer and upon the severity of the performance requirements.

The availability of digital computing equipment within the authors' company for the last three years has provided a powerful new tool for performing numerical calculations and logical decisions at high speed and low cost. Many more alternatives for a particular rating can now be studied to obtain closer to optimum designs in much less time. Calculation methods can now be used which hitherto were too laborious for routine slide rule operations.

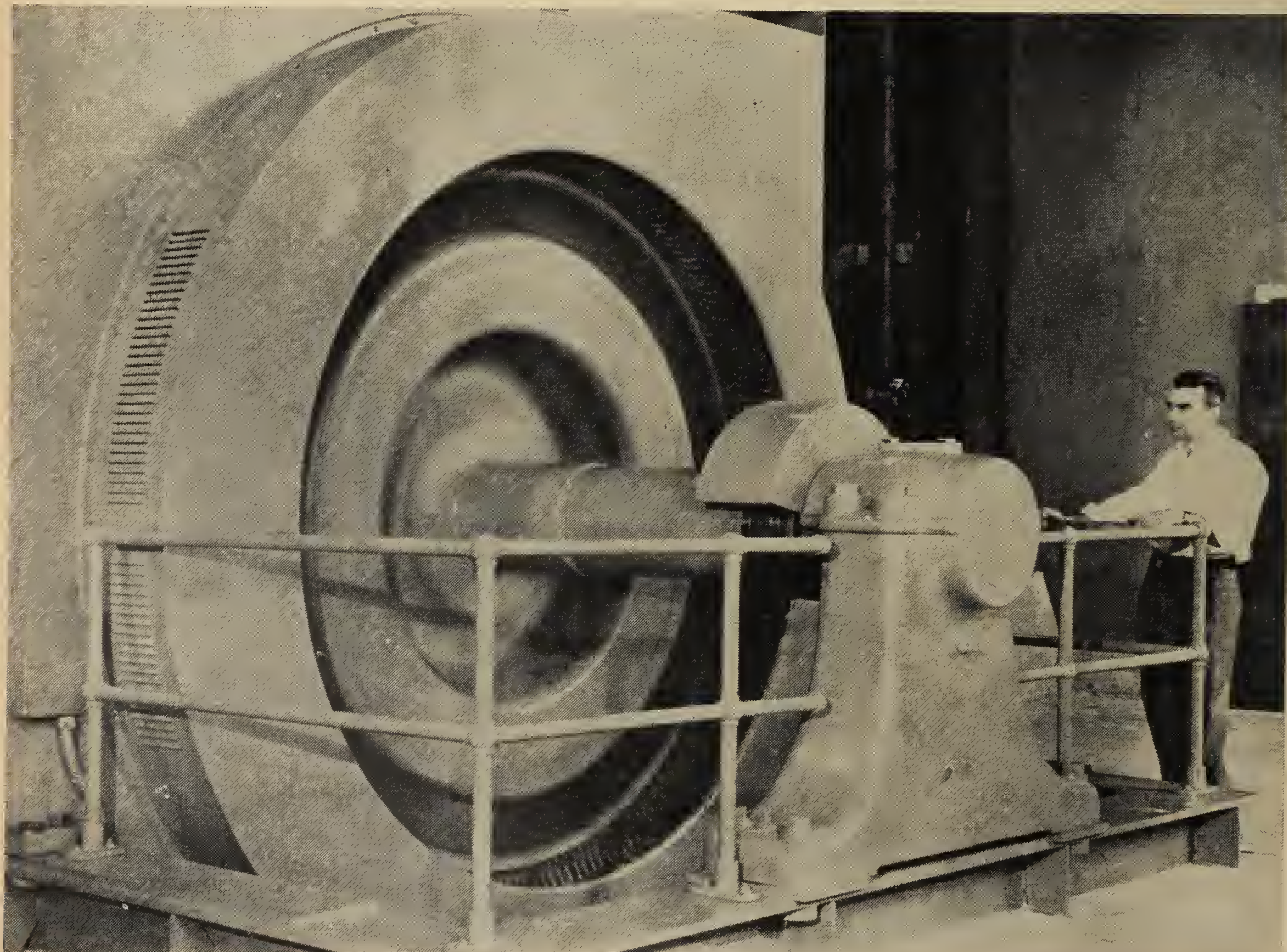
Using the statistical approach and the theory of probability it is now practical and relatively easy to correlate test results from a large number of machines with the new, more precise methods of performance calculation.

With increasing experience, the ability to predict load characteristics has also improved. Whereas in earlier times large factors of safety and margins were used in the motor design to ensure successful operation, present performance predictions, which have been evolved, allow the design of physically smaller and less expensive units with a greater degree of confidence. The development of synchronous and induction motors is a continuing process, and no doubt further improvements are possible despite the fact that over 70 years have passed since their invention.

Conclusions

Knowledge of motor and load characteristics are prerequisites to combining the two for a successful drive. Modern designs and construction features have evolved to produce improved and reliable operation for Canada's particular requirements.

Fig. 8. 4500 h.p.—0.8 P.F.—257 r.p.m.—6600 Volt Synchronous Motor Driving a Pulp Wood Grinder



THE POTENTIAL IN THE FREE-PISTON ENGINE PRINCIPLE

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

A great amount of literature has been published dealing with specific characteristics of free-piston engines. Many of the advantages such as simplicity, good fuel economy, and multi-fuel characteristics have been widely discussed. Furthermore, different possible arrangements have also been written about in a number of publications. Thus on the basis of the above, anybody particularly interested in this field can have a fair understanding of the free-piston engines available and even of some of the engines in the test stage. These early designs, just as with most new developments, represent conservatively designed units to assure the introduction of reliable engines. These first designs can therefore be compared with, for example, early spark ignition (S.I.) and compression ignition (C.I.) engines. Today's free-piston engines, in other words, must be considered as in an early development stage whereas the development stage of modern (S.I.) and (C.I.) engines are advanced designs working near the upper limits of their respective principles. It is the purpose of this paper to point out the not yet utilized potential in the free-piston engine principle and compare it to the potential remaining or further development or advancement possible with the conventional engine principles of today.

THE DIFFERENT Internal Combustion Engines of today are: Spark ignition (S.I.) or gasoline engines; Compression ignition (C.I.) or Diesel engines; Gas turbines (G.T.); Free Piston (F.P.) engines.

In both S.I. and modern C.I. engines the combustion occurs at nearly constant volume. Thus the otto-cycle shown in Fig. 1 can be used to study the influence of compression ratios on efficiency. Both engines are therefore greatly dependent on their compression ratio. The relation between the thermal efficiency and the volumetric compression ratio $r_v = (v_1/v_2)$ is:

$$\eta_{th} = 1 - \frac{1}{r_v^{(k-1)}}$$

where k is the isentropic exponent.

The simple GT can similarly be investigated on the basis of the constant pressure combustion or Brayton cycle shown in Fig. 2. The thermal efficiency for this cycle is usually expressed in this form:

$$\eta_{th} = 1 - \frac{1}{r_p^{(k-1)/k}}$$

where r_p is the pressure ratio of combustion and intake pressure $r_p = (p_2/p_1)$ which in this case (dealing with a steady flow engine) is a more convenient term to establish than the volumetric compression ratio r_v. Since r_v and r_p however are related in the following manner

$$r_v = r_p^{(1/k)} \quad \text{if} \quad r_v = (v_1/v_2)$$

$r_p^{(k-1)/k}$ can be written:

$$r_p^{(k-1)/k} = r_v^{(k-1)}$$

and by substituting. the efficiency term for the Brayton cycle reads also

$$\eta_{th} = 1 - \frac{1}{r_v^{(k-1)}}$$

The combustion process in the F.P. engine is similar to that in the S.I. and C.I. engine and therefore the thermal efficiency can be determined on the basis of the cycle shown in Fig. 3.

The general expression for the thermal efficiency η_{th} is

$$\eta_{th} = 1 - (Q_r/Q_a) \qquad (1)$$

where Q_r = heat rejected
and Q_a = heat added

since the heat in the cycle of Fig. 3 is rejected between state 7 and 1 and is added between state 3 and 4 it follows that:

$$\eta_{th} = 1 - \frac{c_p(T_7 - T_1)}{c_v(T_4 - T_3)} \qquad (2)$$

assuming $c_p(T_6 - T_2) = c_v(T_5 - T_2)$

it follows that

$$T_6 = \frac{c_v}{c_p}T_5 - \frac{c_v}{c_p}T_2 + T_2$$

$$= \frac{T_5}{k} - \frac{T_2}{k} + \frac{T_2 \cdot k}{k}$$

$$= \frac{T_5 + T_2 \cdot (k-1)}{k}$$

since $\frac{P_1}{P_2} = \frac{P_7}{P_6}$

and if the volumetric compression ratio of the compressor is

$$r_{v_c} = (v_1/v_2) = (v_7/v_6)$$

$$\frac{p_1}{p_2} = (v_2/v_1)^k = (v_6/v_7)^k = (1/r_{v_c})^k$$

and

$$T_2 = T_1 \cdot (v_1/v_2)^{(k-1)} = T_1 \cdot r_{v_c}^{(k-1)}$$

and if the overall volumetric compression ratio is:

$$r_{v_T} = (v_1/v_3)$$

$$T_3 = T_1(v_1/v_3)^{(k-1)} = T_1 \cdot r_{v_T}^{(k-1)}$$

and if the pressure ratio is:

$$r_p = (p_4/p_3)$$

$$T_4 = T_3(p_4/p_3) = T_3 \cdot r_p$$

$$= T_1 \cdot r_p \cdot r_{v_T}^{(k-1)}$$

also

$$(v_3/v_2) = (v_3/v_1) \cdot (v_1/v_2)$$

$$= r_{v_c}/r_{v_T} = (v_4/v_5)$$

therefore

$$T_5 = T_4(v_4/v_5)^{(k-1)} = T_1 \cdot r_p \cdot r_{v_c}^{(k-1)}$$

and

$$T_7 = T_6\left(\frac{v_6}{v_7}\right)^{(k-1)}$$

$$= \frac{T_5 + T_2(k-1)}{k} \cdot \left(\frac{1}{r_{v_c}}\right)^{(k-1)}$$

$$= T_1 \frac{r_p + k - 1}{k}$$

By substituting now into (2) it follows that the efficiency for the FP cycle according to Fig. 3 is

$$\eta_{th} = 1 - \frac{1}{r_v^{(k-1)}}$$

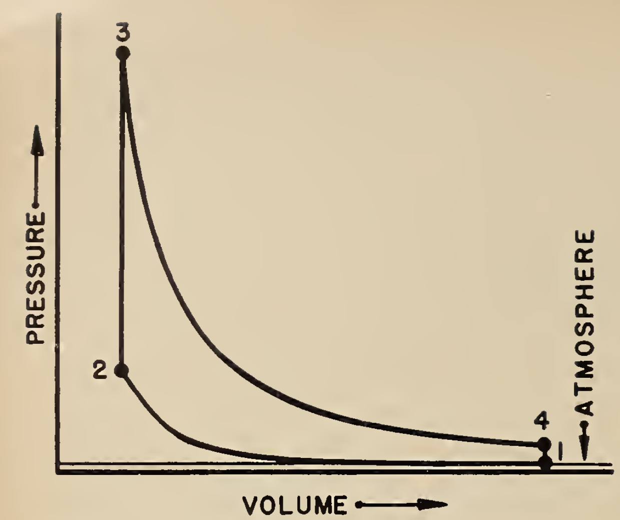


Fig. 1. Otto-Cycle (Constant Volume Combustion)

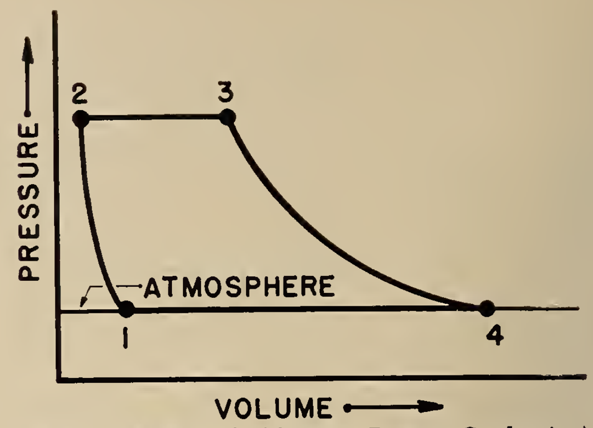


Fig. 2. Brayton-Cycle (Constant Pressure Combustion)

which is exactly the same expression that applies to the other 3 cycles mentioned if r_v represents in the case of the FP cycle the overall or combined volumetric compression ratio of the compressor and engine part.

The expression therefore on the basis of which the thermal efficiencies of the representative cycles of all 4 modern internal combustion engine types can be compared is:

$$\eta_{th} = 1 - \frac{1}{r_v^{k-1}}$$

By finding now the maximum possible compression ratios and their limitations for the above four engine types a valuable indication of their respective actual efficiencies is available.

S.I.—or gasoline engines

Since S.I. engines depend on a fairly homogeneous air to fuel ratio throughout the combustion chamber the air-fuel mixture enters the cylinder during the intake period and a combustible mixture is compressed to a state just below its self-ignition point. There the spark ignites the mixture in one location and from here the flame propagates through the rest of the combustion chamber under controlled combustion conditions. In case the compression ratio is higher than the self-ignition point of the fuel permits, uncontrolled combustion starts ahead of the spark ignition in many different locations of the combustion chamber and so-called knocking occurs, which is a phenomenon harmful to vital parts of the engine and can under no circumstances be tolerated for any length of time and is furthermore an inefficient way to release the fuel energy.

An $r_v = 10$ must be considered very close to the economical and practical limit since otherwise fuel cost would become so high that the gain in efficiency would not balance, and even greater specific output would not warrant the increase.

The Octane number or cost of fuel are therefore the limiting factors for the compression ratio in the S.I. engine.

C.I. or Diesel engines

In the C.I. or Diesel engine only the air is compressed during the compression stroke of the piston and to a state that is substantially above the self-ignition point of the fuel used. Then the fuel is injected into the highly compressed air and around each fuel particle the combustion occurs independently of the overall air to fuel ratio in the combustion chamber as long as each particle finds enough air for its proper reaction. Knocking in the Diesel engine occurs when too much fuel has been accumulated in the combustion chamber before the combustion starts. This happens if the chemical and physical ignition—delay period (which is the time that the fuel requires from the time of entering the combustion chamber until it starts actually burning) is too long. Since the ignition delay period decreases with higher temperatures and pressures i.e. with high compression ratios, it is very desirable in C.I. or Diesel engines to have as high as possible r_v for good combustion behaviour.

With increasing compression ratios, however, the high pressures in the engine require heavy engine structures and at compression ratios above 22 : 1 reach values that result in extremely high bearing pressures in the connecting rod and main bearings besides undesirably high loading of the pistons and liners due to high side thrust.

Therefore mechanical and structural requirements constitute the limitation for the compression ratio in the Diesel or C.I. engine.

Gas Turbines

Gas turbines are steady flow type of engines which means also that the fuel is continuously burnt in the combustion chamber, whereas in the reciprocating type of engines dealt with earlier, the fuel is burnt intermittently.

This means that at the same maximum temperature in the cycle (which as expressed in the efficiency terms is the criterion for good thermal efficiency) the combustion chambers of reciprocating engines have to stand a thermal load only equivalent to the mean cycle temperature whereas in gas turbines the combustion chambers have to stand thermal loads equivalent to the maximum cycle temperature. As shown in Fig. 4 the maximum temperature is substantially higher than the mean temperature and compression ratios in gas turbines are therefore to be kept low.

Metallurgical or material requirements, therefore, limit the use of high compression ratios in gas turbines.

F.P. Engines

The reasons for low compression ratios and the limiting factors for the other 3 engine types in summary were:

S.I. Engines: Air-fuel mixture has to be compressed therefore knock-characteristics of fuel limit r_v. Above $r_v = 10$, fuels get too costly.

C.I. Engines: Load on bearings and pistons put limit to r_v. Above $r_v = 22$ engines get too heavy and life of engines too short. Fuel imposes here no limitation on r_v.

Gas Turbines: Because of continuous combustion, maximum temperatures in combustion chamber and in turbine impose limit on r_v. Above $r_v = 7$ combustion chamber and turbine blade materials do not stand up.

A look at the F.P. engine power plant shows that here the Diesel or C.I. principle is compounded with the gas turbine and in such a way that in the Diesel or C.I. part of the F.P. unit gas is produced to feed the turbine which produces the net power—and no more—of the compound power plant. Because of this characteristic of the F.P. unit itself it is usually called F.P. "gasifier".

Since in the F.P. gasifier the Diesel or C.I. principle is applied to convert the fuel energy into work, it is insensitive to fuel and from a fuel point of view imposes no limit on r_v. Furthermore—as indicated in their name and apparent from Fig. 5—in F.P. engines the two pistons are not connected to any drive mechanism or mechanical power pick-up (except for auxiliary drives) but rather oscillate freely in opposed reciprocating motion inward and outward. Except for losses, all the work done by the Diesel or power parts of the pistons is transmitted to their directly connected compressor parts. Thus bearings are eliminated and side thrust is negligible. In this manner it is possible to fully utilize the Diesel or C.I. principle together with extremely high compression ratios r_v, that would in the conventional type of Diesel or C.I. engine be intolerable.

Similarly the other part of the compound F.P. power plant, the turbine, is employed in such a way that its positive characteristics such as structural simplicity, low weight, superior torque characteristics, and the ability to expand the combustion gases to atmosphere etc. are fully utilized ; the difficulties resulting from high entry temperatures however are eliminated since the temperatures of the gases supplied by the gasifier and entering the turbine are far below those in a conventional gas turbine. The reason for this is that the F.P. turbine part has to provide only the net work of the compound power plant, whereas in the conventional gas turbine the turbine wheel has to provide this net work in addition to the compressor work. The net work in the conventional gas turbine is only 1/3 of the total work to be supplied by the turbine and remaining 2/3 of the work done by the turbine has to be fed back to its own compressor (rotary). Since in the F.P. compound power plant this compressor work is already done in the (intermittently working) gasifier, the enthalpy of the gases and, as said, their temperature for the same net horse power, are substantially lower than in the conventional gas turbine.

Both limitations (regarding the diesel part as well as the turbine part of the F.P. compound power plant) are overcome this way.

Because of the above, present day F.P. engines work with volumetric compression ratios of 40 to 60 : 1. Ratios of 80 : 1 and up are within the scope of relative short range development work and do not represent the limits as in the cases of S.I., C.I. engines and gas turbines.

Quoting the efficiencies corresponding to the r_v values discussed will help to put the potential of the F.P. principle in its proper perspective :

TABLE I

Representative values of r_v of different engine principles and corresponding thermal and actual efficiencies in %*

	GT	*SI*	*CI*	*FP*	
				Present	*Foreseeable Future*
r_v	7 : 1	10 : 1	22 : 1	40 : 1	80 : 1
η_{th}	54.1	60.2	70.9	77.2	82.7
Actual Efficiency	22	28	36	38	41

*Values of actual efficiencies of G.T., S.I. and C.I. engines from p. 235[1].

To evaluate the figures realistically it has to be considered that the thermal efficiencies derived above referred only to the theoretical cycles, and that actual thermal efficiencies besides r_v are influenced by a number of other circumstances such as fluid and mechanical friction losses, heat-transfer rate, combustion efficiency, state of development, etc., so that the percentage increase of thermal efficiency is not the same as the increase of the actual efficiency. The general trend, however, is (with few exceptions) the same as indicated by the thermal efficiency.

It can be seen—even though to different degrees—that the trend is upward and it should be recalled again that G.T., S.I. and C.I. engines work on their upper limits after over half a century of development and research effort, whereas the first F.P. gasifiers were installed only a few years ago.

Moreover, the gain with this new principle is not achieved with a more complicated but rather with a greatly simplified engine that has numerous advantages over the conventional types. Although often quoted[2,3,4,5] a summary will again be of value here.

Multifuel Characteristics

F.P. engines will operate on practically any fuel the injection pump can handle. Bunker "B" and Bunker "C" oil are successfully in use in several installations[2,3,6,7,8] : stove oil or Diesel fuel are the normal fuels in most applications today and ether, gasoline, lubrication oil and mixtures thereof, vegetable oil etc. have been burnt without re-adjusting the fuel injection pump.

The reasons for this will be apparent from a study of Fig. 7.

In regard to the combustion chamber conditions it should be noted that even though the compression end temperature t_3 is substantially above, the combustion end temperature t_4 is below that in S.I. and C.I. engines because of the unusually high air to fuel ratio (based on the air trapped in the combustion section) which results in a lesser degree of chemical attack on pistons and cylinder.

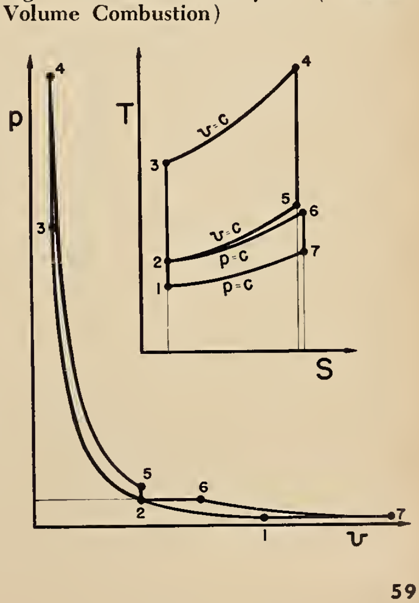
As for the exhaust port deposits, the situation is such that the part of the gas delivered which contains the products of combustion passes the exhaust ports at temperatures between states 5 and 6, which, because of the high back pressure at 6, are much higher than those in the S.I. or C.I. engine (which leave these engines at temperatures equivalent to state 5′) resulting in practically no deposit formation.

In spite of these high temperatures the mean temperature of the gas entering the turbine, as well as the mean temperature of products of combustion plus air passing through combustion cylinder and exhaust ports, is lower than the exhaust temperatures of S.I. and even C.I. engines because of the additional amount of air supplied by the compressor parts of the gasifier which passes through combustion cylinder and exhaust ports at a temperature t_2 and mixes with the products of combustion at temperature t_6 before it enters the turbine at a mean delivery temperature $t_{6'}$ also substantially below the entry temperature of ordinary gas turbines thus resulting in a greatly reduced tendency of chemical attack on vital turbine parts in the F.P. turbine particularly when residual fuel is used.

In order to avoid possible confusion it might be stated here, regarding the difference between Fig. 7 and 3, that the analysis based on Fig. 3 is correct in spite of the fact that in the derivation of η_{th} of the F.P. engine no consideration was given to the mixing of excess scavenging air and products of combustion.

The reason for this is that in the derivation of the η_{th} term it is sufficient to consider only the mass of working substance participating in the actual combustion cycle, when it is assumed

Fig. 3. Free Piston-Cycle (Constant Volume Combustion)



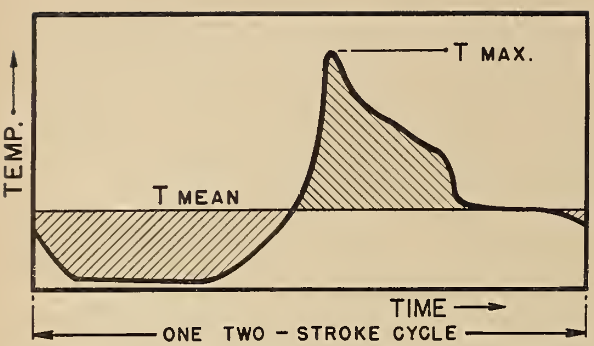


Fig. 4. Gas Temperature in Two-Stroke Diesel Engine Cylinder

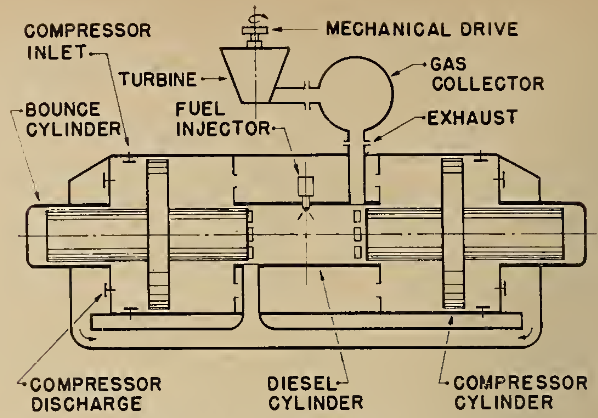


Fig. 5. Diagrammatic Free Piston-Turbo Set

that the additional mass of air supplied by the compressor parts of the gasifier by-passes the combustion section and is then expanded in the turbine back to atmosphere.

Simplicity

As explained above no crankshaft, connecting rods, bearings, camshafts, valve mechanism, flywheel etc. are required, resulting in a structurally very simple engine.

Compactness

Due to their structural simplicity, the high degree of supercharging and the full expansion down to atmospheric pressure F.P. engines are very compact and have a low weight per hp.—including turbine and gearbox where necessary.

Dynamic Balance

With the absence of any drive mechanism and with the opposed reciprocating motion of the two piston assemblies which are essentially the only moving parts in the engine, the gasifier is inherently balanced and since there is no vibration, foundations can be substantially lighter and less costly.

Flexibility of Installation

Since there is no common crankshaft required for a multicylinder installation there is no reason to build multicylinder units. It is, on the contrary advantageous to produce single cylinder units which can be either suitably coupled to power packages or independently installed in sections of the power plant or vehicle, which are of least value otherwise and that can result in optimum weight distribution[9]. The only connection necessary in a multicylinder installation (there have been up to 48 cylinders in one plant)[10] is the delivery piping to the turbine which is either part of the vehicle structure[11] or of relatively small volume, and, as mentioned above, in subject to lower temperatures than those of ordinary S.I. or C.I. engine exhaust pipes.

Flexibility of Operation

In most installations there will be more than one and at least two cylinders or gasifiers installed. Assuming an installation of 4 cylinders or gasifiers on a single turbine it can easily be seen that at 1/4 load for instance 3 of the 4 gasifiers can be shut off and at 1/2 load only 2 will be running, etc. The result is a very flat efficiency or specific fuel consumption (SFC) characteristic over the whole load range. The specific characteristic is of course dependent on the turbine design selected and will vary with individual application.

In contrast to the above it should be noticed that in the conventional S.I. or C.I. engine all cylinders have to be run at the part-load point desired resulting in relative high S.F.C. at part-load.

Reliability

Here again the independence of the individual gasifiers in a multicylinder installation results in an unusually high reliability. Failure of one cylinder in a conventional S.I. or C.I. engine will stop the whole engine, whereas in a F.P. installation the rest of the gasifiers will not be affected by the failure of one gasifier and, moreover, the unit that failed can be repaired while the other units perform their normal duty.

In installations where this point is of particular importance provision can easily be made in the form of an additional fuel supply between gasifier and turbine (afterburning) so that in case of failure of one or two gasifiers, the rest of the gasifiers will still provide full power requirement.

Overload

As mentioned under the previous heading fuel can be introduced between gasifiers and turbine in order to achieve an overloading. The reason for this is that the temperature of the delivery gases is relatively low and that the overall air-to-fuel ratio of these gases is so high that considerable amounts of fuel can be burned after the gases have left the gasifier without getting smokey combustion.

This is, of course, not the most efficient way to burn the fuel but in emergency cases, this characteristic can be of great value. Compared with any of the conventional engines the F.P. power plant has this outstanding advantage which furthermore is not subjected to the short time restriction usually connected with such overload conditions.

Maintenance

The maintenance costs are directly in relation to the smaller number of parts that the F.P. installation has compared with the S.I. or C.I. engine. Also because of the structural simplicity the time required to carry out the work is extremely short and the required skills are less. The lack of bearings etc., side-thrust, and some of the other characteristics mentioned above such as deposits, etc., results in long runs between overhauls. The required time to completely disassemble or reassemble a gasifier is considerably shorter than for any equivalent power plant of conventional design.

Throttle Response

The pistons in the gasifier are essentially the only moving parts and since they operate with their natural frequency between their respective "thermodynamic springs" the response of the gasifiers to the fuel lever position is extremely good ; far better than that of the conventional gas turbine and better than that of S.I. and even C.I. engines.

The response of the whole power plant is to some degree dependent on the gas volume in the piping between gasifier and turbine but this is negligibly small in most installations.

Torque Characteristic

On the usual F.P. gasifier—turbine installation the torque characteristic is essentially that of a hydraulic torque converter (i.e. the stalling torque is approximately 3 to 3.5 times the full speed torque). Thus, for automotive use the F.P. power plant can be considered as having a built-in torque converter at no extra cost. This point together with extremely good throttle response makes it in this respect the most desirable power plant available. The smooth power supply from the turbine has resulted in successful applications to locomotives[12,13] without any intermediate electric equipment.

Economy of Production

Here the simplicity of the engine again results in considerable advantages. By the elimination of many of the intricate and expensive parts of conventional engines far less special machine tools are required thus reducing initial manufacturing plant investment to a fraction, particularly in the cases where a whole line of engines are considered, since one size of gasifier will serve a large range of horse power requirements.

Economy of Operation

Overall specific fuel consumption at the present status of 0.365 lb. fuel/S.H.P. hr. and less[14] has been achieved. This compares very well with the best Diesel engines built and it should again be recalled that this may be done with much cheaper fuel than the comparable Diesel engine would burn.

Conclusion

From this summary it can be seen that F.P. engines, even at their present status, not only compare very well but are in many regards superior to conventional power plants. Specific areas, however, that can still be considerably improved are : power to weight ratio, compactness and fuel consumption. As was mentioned earlier, part of the air supplied by the compressor does not participate in the actual thermodynamic cycle. Since the power produced in the Diesel section of the gasifier has to be used up by the compressor parts in order to achieve the necessary balance within it, the overall air to fuel ratio decreases with increased compressor delivery pressure until it reaches a value that cannot be reduced further (smoke limit of engine)[15]. This critical compressor discharge pressure is about 12 atmospheres or 170 p.s.i.a. which is equivalent to a volumetric compressor compression ratio of $r_{vc} = 6$. Compressor compression ratios of the F.P. engines quoted above are about $r_{vc} = 3.1$. The result of any increase over the present r_{vc} will be better overall efficiency and fuel consumption, still lighter and more compact units

The increase in efficiency is, among other factors, apparent from the earlier study of η_{th}. Reduction in weight and greater compactness result from the higher degree of supercharging and from the increased stiffness of the thermodynamic springs which increase the speed of the pistons.

One further means of increasing efficiency is the raising of the compression ratio in the Diesel section ; another way of getting lighter and more compact units, even after the above mentioned critical compressor discharge pressure has been reached, is supercharging of the compressor sections of the gasifier[16]. It is also worth mentioning that the output of the F.P. power plant increases directly with the speed of the pistons for a given engine design and inversely proportional to the square root of the weight of the pistons.

In conclusion it must be said that the above possibilities cannot be immediately materialized to their full extent and further development and research work is necessary to reach the limits indicated. Since conditions are considerably different from those in conventional engines, new approaches must and can be found, and the rate of progress will greatly depend on the engineering ability and ingenuity of the designer as well as on the effort put into the further development of this interesting and promising type of engine.

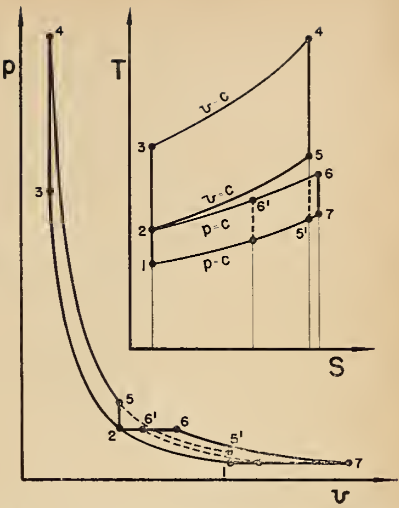
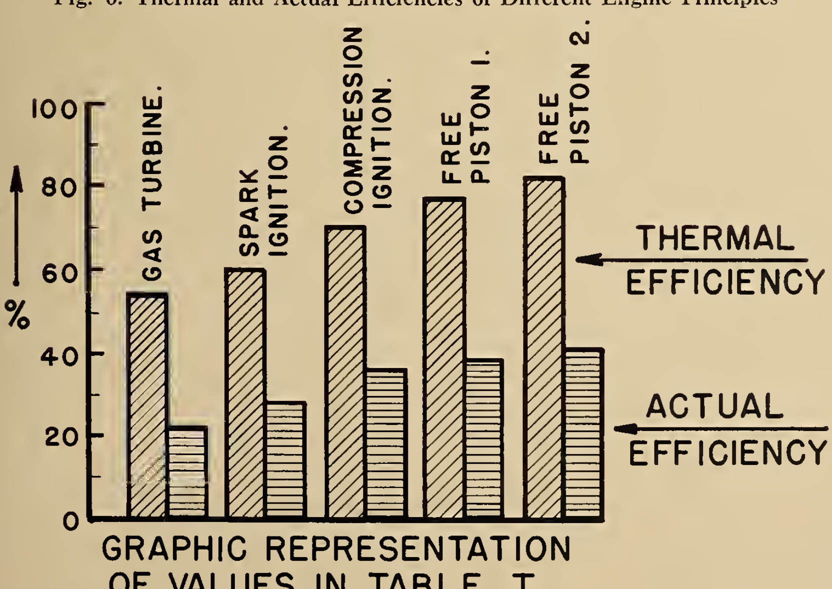


Fig. 7. Free Piston-Cycle Indicating Effect of Excess Air

Fig. 6. Thermal and Actual Efficiencies of Different Engine Principles



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LIQUID PETROLEUM GASES AS FUELS FOR AUTOMOTIVE ENGINES

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May, 1960.

Supplies of butane and propane are dependent, since they are by-products of refineries and conservation plants, on markets for oil and gas. An analysis of their market has been prepared by R. W. Wright[1] *which shows they are subject to surplus conditions. New markets, particularly seasonal ones, are required to utilize butane and propane locally. Research has been directed to automotive use since farm engines equipped to burn these fuels could take some of the acute summer surplus.*

BUTANE is a hydrocarbon which boils at 32°F. It has an octane rating of 100, making is suitable for engines. Propane boils at —44°F, and has an estimated octane rating of 130. Propane is particularly suitable for high compression engines. Both fuels are difficult to handle since within the range of normal pressures and temperatures they may be either a liquid or a gas. Propane has been the only LPG fuel used extensively in western Canada.

Analysis of Commercial Conversion Equipment

Equipment in use by trucking firms and farmers occasionally gives trouble. When propane is used, it is difficult to set the adjustments correctly because the fuel has such a high octane rating that it will burn quietly even under improper conditions. Although the equipment at present available for conversion to LPG has been refined and when properly set may give adequate service, it is much more sensitive than the conventional gasoline system. A typical system is shown in Fig. 1.

At ordinary temperatures no fuel pump is required since pressure within the tank drives the liquid through the system. Fuel moves through the filter to a pressure reduction valve, to a heat exchanger, where it becomes a gas, through a secondary pressure control valve and to the carburetor. Heat is supplied to the heat exchanger from engine cooling water.

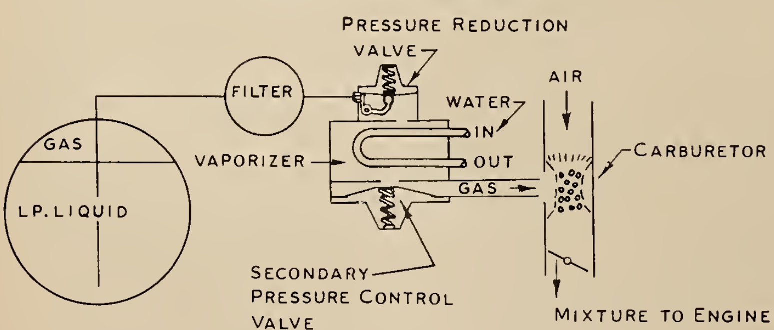
When analyzed, it is obvious that the system will not work for butane below 32°F. Even propane will not work well in cold weather unless some low boiling fuel (ethane, methane) is added. Theoretically, the system should work well for propane at any temperature above freezing but practically this often has not been the case.

Investigations of Automotive Use

Although the Edmonton Transit System is pleased to operate some 30% of its fleet on propane, other fleet operations in Alberta have not been so fortunate. Inconsistency of performance even with factory-equipped units has caused some trucking firms and many farmers to give up their use of propane. In some cases individuals have obtained better performance temporarily on propane by increasing the compression ratio. Where the engine has not been built to take the increased bearing loads this has resulted in failure. Otherwise where compression ratios have not been utilized, the inconvenience of low mileage per gallon, extra pressure tanks, hazards and inadequate service have discouraged many users.

The chief advantages of LPG are long engine life, extra power and cheap fuel. The chief disadvantages are inconsistency in performance and hazards such as leaks which can cause fires. Where propane has been successful, inconsistency has been overcome by careful fleet maintenance and disciplined periodic readjustment, and hazards have been reduced by care, control and education by trade and regulatory organizations.

FIGURE 1. LPG Carburetion



Research

F. V. MacHardy of the University of Alberta did some preliminary work[2] on vapour distribution to cylinders and on carburetor performance. While this portion of the equipment performed satisfactorily, he pointed to the pressure regulators-heat exchanger combination as a "critical component" of the apparatus. The heat exchanger during his tests would refrigerate until it was not performing adequately. Trucking firms which had been interviewed claimed that this portion of the equipment was too sensitive and gave them trouble such as power loss. Burned valves and scored pistons were attributed to the heat exchanger in two possible ways.

The first theory is that overheating of the engine can be caused if the demand for vapour is so great that the heat exchanger cannot supply heat quickly enough and the vapour passing from the heat exchanger through the secondary pressure control valve has such a low pressure that when mixed with the normal amount of air in the carburetor the resulting combination is lean in fuel.

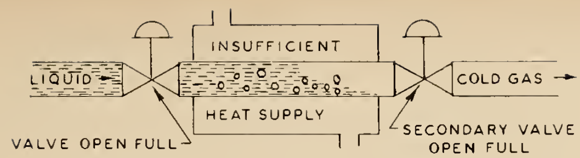
The second theory is that a hot engine will heat the exchanger so that its internal pressure is relatively high, causing the secondary pressure control valve to allow less weight of fuel to pass into the carburetor. The two theories are illustrated in Fig. 2.

The apparatus used in the tests consists of a 60 hp conventional gasoline engine mounted to a hydraulic brake[a], a conversion kit for LPG, 23 gal. and 4 gal. propane tanks. For the first test a separate heating and circulating unit was attached to control the heat in the exchanger. The purpose was to allow the heat exchanger to refrigerate and to check the horsepower as the temperature fell.

Under full load at several engine speeds a characteristic gradual decrease in horsepower was obtained which climaxed in engine stoppage. A series of curves was obtained for propane and butane. (Fig. 3.). Results are shown in Table I.

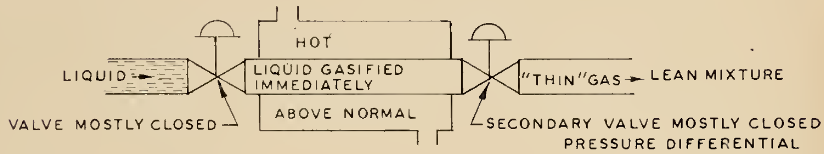
It is evident that under load and

(a) Through the kind co-operation of the Department of Agricultural Engineering, University of Alberta.



FIRST THEORY - INADEQUATE HEAT EXCHANGE

FIGURE 2.



SECOND THEORY - OVERHEATED VAPORIZER

in conditions where the engine cooling fluid which passes through the heat exchanger is either cold or the quantity is insufficient, the function of vapourization is inefficient and sometimes stops altogether. Full load conditions showed a start of this phenomenon for propane at about 30°F and for butane at 75°F.

Under ideal conditions the conventional equipment may prove satisfactory, but when speed and load change, it may not function well or may even cease to function. There is therefore a need for improvements to the available equipment.

Design of Alternate Equipment

(a) *Butane Characteristics:* Since butane is 100 octane fuel, it may best be used in conventional automotive engines. Two methods of achieving this are apparent: (i) to cool the fuel into liquid state and allow it to operate in a normal gasoline carburetor, and (ii) to vapourize the butane under controlled conditions of temperature and pressure, thus to allow accurate mixing of gas with air in the carburetor.

(b) *Propane Characteristics:* Propane has an estimated octane rating of 130 and therefore may be burned in engines whose compression ratios are as high as 16 to 1. High compression thus can make use of a greater percentage of oxygen in the air-propane mixture and can be somewhat more efficient than other types of engine. Application of this principle may be made (i) in converted gasoline engines whose compression ratio has been raised above 8 to 1 and in converted diesel engines with the further addition of an ignition system and (ii) in diesel engines as a fuel additive or in what is often called "dual-fuel" where the diesel ignition supplies the start of combustion and the propane provides variable power through a carburetion system.

Experimental Application

Since the simplest and least expensive technique for butane utilization consists of vapour withdrawal it was decided to run a series of tests with a heated tank, simple pressure control valve and elementary mixer for a gasoline engine. The gasoline equipment was modified simply to selectively bypass the gasoline. A mixer with adjustable venturi was placed on top of the gasoline carburetor, a plastic hose was arranged to carry the gas from the heated tank and a connection made to the engine cooling water. The apparatus is shown schematically in Fig. 4.

The vehicles used were started on gasoline, and when warm, the gasoline was switched off, allowing the engine to use up the fuel in the carburetor

Table I—Cutout Temperatures for Propane

	Time	*Speed*	*Load* lb.	*Horsepower*	*Temperature* °F	*Remarks*
1600	2:20	1600	94	37.5	100	Glycol hot
	3:20	1500	85	33.8	−3	Engine missing
In the test above, the vapourizer allowed liquid to pass over at +40°F.						
2000	2:35	2000	94	47.0	112	Glycol hot
	3:45	1500	80	30.0	−4	Engine hunting
In the above test, the vapourizer allowed liquid to pass over at 0°F. In this state the hose was ¼ full of liquid propane.						
2500	2:30	2500	84	52.5	115	Glycol hot
	3:18	2500	60	37.5	+3	Cutting out
Liquid passed over at 31°F. Some backfiring in the muffler.						
3000	10:55	3000	74	55.5	102	Glycol hot
	11:20	3000	69	51.8	18	Hunting
Liquid passed over at 38°F.						

Table II—Cutout Temperatures for Butane

1:40	1600	85	34.0	74	Hot
2:25	1600	84	33.6	40	Stopped
1:30	2000	88	44.1	128	Hot
2:20	2000	85	42.6	62	Stopped
1:35	2500	90	56.3	82	Hot
1:45	2500	90	56.3	66	Liquid entering

bowl. As the engine began to "fade" butane was switched on and operation continued in a very satisfactory manner. The experimental tank was not insulated but this was considered necessary during cold weather. A test engine mounted on an hydraulic brake was then equipped with this apparatus and results were quite satisfactory. Tables of performance on gasoline and butane are given for this engine (Table III).

In the field of diesel dual-fuel, experiments were carried out with the assistance of the Edmonton Transit System. An older type of bus was made available for testing. Preliminary work involved the adjusting of amounts of propane to diesel by manual control. Tests on hills showed a very great increase in power when propane was allowed into the intake manifold. However, the return to normal load on the level runs caused some difficulty when manual control was used.

The engine governor in the diesel operates a rack and pinion mechanism to change the amount of diesel fuel passing into the engine. When propane was added to the idling or low speed condition, the engine tried to speed up, but the governor, being set by the accelerator pedal for lower speed, sensed the higher speed and cut the diesel injection to the off position. Without diesel ignition the propane could not ignite, and this stalled the engine.

The apparatus shown in fig. 6 was developed. The fuel pump rack was connected to a butterfly valve which controlled the pressure in the plenum chamber of the apparatus and thus controlled the amount of propane drawn in. Diesel and propane were supplied together and controlled together by the engine governor. The power increase was evident and performance was especially good on acceleration.

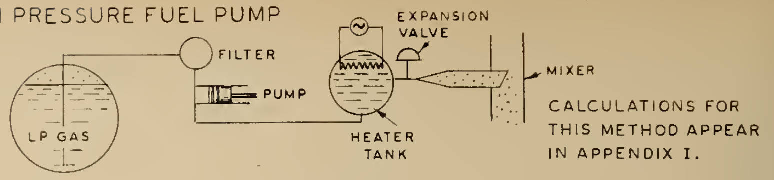


FIGURE 5.

Table III—½ Hour Runs—Hydraulic Brake Chevrolet 6 Engine. 65 h.p.

Test	*R.P.M.*	*Load*	*HP*	*Fuel-lb.*	*lb/HP.Hr.*	*Thermal Effy.*	*Water temp.*
			(A) Butane Tests				
1	1500	93	35	7.0	0.400	28.9	160
2	1500	90	33.7	8.0	0.475	24.3	180
3	2000	92	46	9.5	0.414	27.9	180
4	2000	93	46.5	12.0	0.516	22.4	180
5	2500	87	54.5	13.5	0.495	23.3	180
6	2500	87	54.5	13.0	0.478	24.2	180
7	3000	86	64.5	13.5	0.419	27.6	180
8	3000	80	60	14.0	0.467	24.7	180
			(B) Gasoline Tests				
9	1500	100	37.5	9.25	0.495	23.9	180
10	1500	102	38.2	9.50	0.497	23.7	180
11	2000	99	49.5	12.0	0.485	24.4	180
12	2000	100	50	13.0	0.520	22.7	180
13	2500	86	53.5	14.5	0.543	21.8	180
14	2500	88	55	14.75	0.536	22.0	180
15	3000	86	64.5	17.0	0.527	22.4	180
16	3000	88	66	16.75	0.507	23.3	180

To discover how much power had been added, the bus was placed on a wheel dynamometer at the Edmonton Transit System. With the rack set to 75% of maximum power the bus produced 55 wheel hp at 30 m.p.h. on straight diesel. It was not possible on this model to operate at full horsepower due to the extensive modifications required.

When converted to dual-fuel with about 75% diesel and 25% propane the horsepower at 30 m.p.h. was increased from 55 to 103 hp.

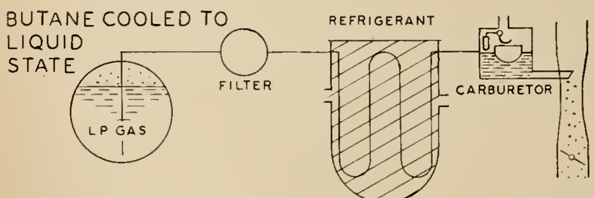
The next tests performed on the bus showed a saving in fuel. Table IV shows a typical pattern taken as an average of several 20-mile runs on dual-fuel.

Future Research

Although the techniques mentioned above are suitable for conversion of gasoline and diesel engines, some modifications and further experiments will make the applications much more useful. For example it would be more satisfactory if all of the high-pressure apparatus used in regulating the amount of LPG were placed inside the fuel tank, so that only low-pressure or pressure lower than atmospheric lines would emerge from the tank. This would eliminate much of the danger due to leaks caused by vibration and would prevent any tampering with sensitive adjustments. This system could be applied both to butane and propane. Also a satisfactory gas producing apparatus of this kind is necessary before much work can be done on the propane-diesel engine.

On the diesel side, many complaints from cities about smog have been voiced. When a diesel accelerates, extra fuel is pumped into the nozzles and is not burned effectively until the engine reaches the proper speed. Propane burns so much more readily that its addition has the possible advantage of overcoming the acceleration smoke. Some experiments in this field have been carried out in Los Angeles. The ideal diesel-propane combination may be a pilot amount of diesel for simplified diesel pumping, utilizing constant quantities of

FIGURE 3.



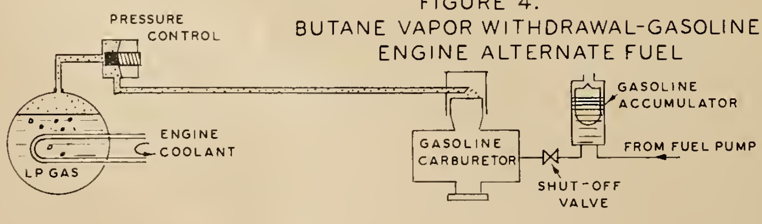


FIGURE 4.
BUTANE VAPOR WITHDRAWAL-GASOLINE ENGINE ALTERNATE FUEL

diesel fuel and obtaining variations in power requirements by throttling the propane. Information needed in this field is the proper ratio of diesel to propane for each power condition.

Conclusions

It has been found that the most straightforward technique for utilization of butane and propane is the heated tank and vapour withdrawal system. The work done on vapour withdrawal provides a simplified system for conversion with conventional piping and no unusual techniques. The diesel-propane dual-fuel engine holds promise of higher than normal efficiencies through a wide range of speeds. Research done thus far will enable operators to experiment with this technique for improved operating characteristics.

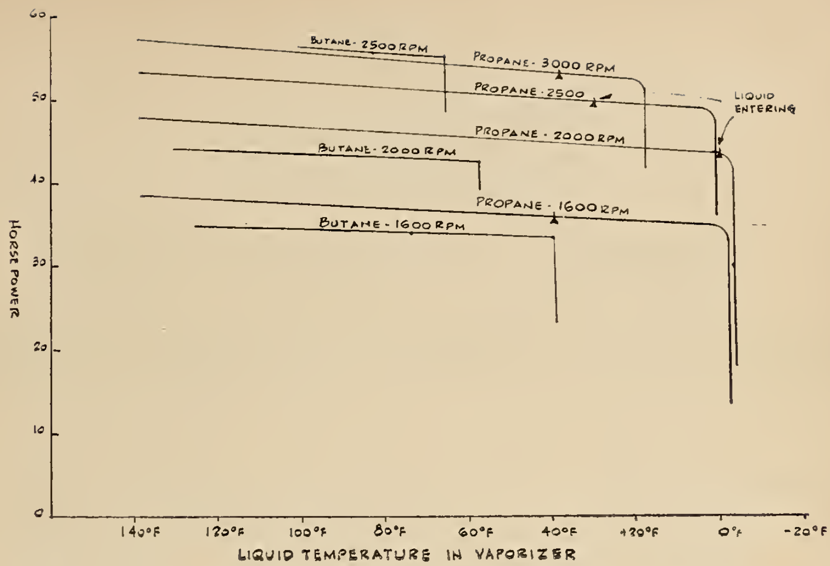


FIGURE 7. Temperature Reduction Curves—Commercial Vapourizer 200 hp.

Table IV.

Test performed on economy April 21, 1959				
Diesel Run:	Start	46 lb.		
	Finish	30 lb.		
		16 lb.		
Length of run 20 miles at 30 m.p.h.				
Dual-fuel Run				
	Start diesel fuel	46.5 lb.	Start propane	48.5 lb.
	Finish diesel fuel	36.5 lb.	Finish propane	43.0 lb.
	Total	10.0 lb.		5.5 lb.
Length of run same as above at 30 m.p.h.				

APPENDIX I

Calculations for adding heat to liquid fuel under pressure, then expanding to gas form.

Assuming initial conditions to be 35° F and 14.7 p.s.i. in the liquid form for propane:

Heat in liquid = 181.6 BTU/ #

Initially, heat and pressure are required to raise the propane to a state from which by adiabatic expansion it will be ready for carburetion. By reverse calculation, using a Joule-Thompson relation for approximating adiabatic expansion:

$$T = \frac{RT_1^2 \log_e (\gamma_1/\gamma_2)}{(Cp)m(T_{R1} - T_{R2})Tc}$$

where

T = change in temperature
R = gas constant
T_1 = initial temperature absolute
$(Cp)m$ = mean specific heat at constant pressure
γ_1 = activity constant at T_1
γ_2 = activity constant at T_2
T_{R1} = (T_1/T_c) where Tc = critical temperature and
T_{R2} = (T_2/T_c)

By bracketing and graphical extrapolation it is found that if

$$T_2 = 459.6° \text{ A}(32°\text{F})$$

then T_1 is 616.6°A (or 156.7°F) from the above expression.

Utilizing adiabatic expansion, P_1 is determined to be 150 p.s.i. approximately.

From tables,

At 10 atmospheres and 156.7°F
Heat in the liquid = 252.3 BTU/lb.
Latent ht. of vapourization = 143.1 BTU/lb.

Total heat in the vapour = 395.4 BTU/lb.

Final conditions 35°F and 14.7 p.s.i., from tables

Total heat in the vapour = 181.6 BTU/lb

Heat to be added at 10 atm. and 156.7°F is

395.4 − 181.6 = 213.8 BTU/lb.

To calculate volumes:

At 156.7°F volume of the liquid is .113 gal (Imperial)/lb.

At 32.2°F volume is 0.095 gal/lb.

Assuming a heating value of propane at 21560 BTU/lb and a 60 hp. engine at 25% thermal efficiency,

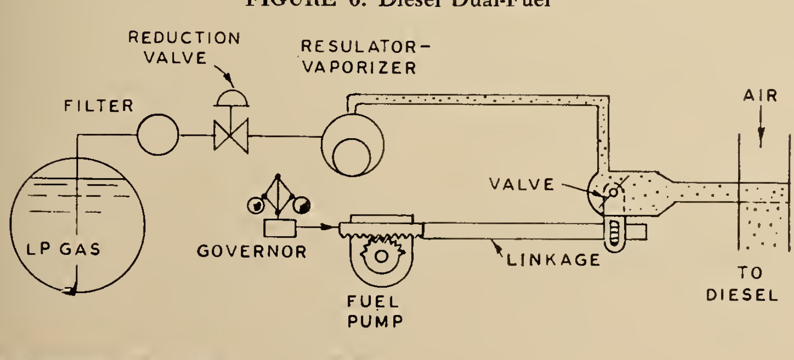
$$\text{Lb. propane/hr.} = \frac{100}{25} \times \frac{60}{21560} \times \frac{3300 \times 60}{778}$$

$$= 28.4 \text{ lb/hr.}$$

$$\text{Maximum volume} = 28.4 \times .113 = 3.2 \text{ gal/hr.}$$

with the above data a heat exchanger may be designed to take a pressure of 10 atmospheres. An immersed pump of the flexible metal diaphragm type is suggested for boosting pressure from that within the supply tank to the pressurized heat exchanger.

FIGURE 6. Diesel Dual-Fuel



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LOAD—FREQUENCY CONTROL SYSTEM OF THE MANITOBA HYDRO-ELECTRIC BOARD

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May, 1960.

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Interconnection between neighbouring power systems is a natural evolutionary process which affords each of the member systems the inherent advantages of economy and reliability of a large generating system without the encumbent and often disproportionate expense of added power developments which can accrue to the individual system in attempting to provide a degree of these advantages for itself. Interconnections offer not only the attractions of greater diversity and reliability through the sharing of generating capacity but also the economy of lowest incremental energy production which can be realized on a larger, more broadly dispersed system and the deferment of capital investment for new machine installations.

IN 1956 The Manitoba Hydro-Electric Board (M.H.E.B.) and the Northwestern Region of The Hydro-Electric Power Commission of Ontario (H.E.P.C.O.) interconnected their respective systems with an 83 mile, 138 kv. single circuit tie-line. Three years later a 170 mile, 230 kv. line, to be operated initially at 138 kv., was projected for completion in 1960 to interconnect the networks of the Saskatchewan Power Corporation (S.P.C.) and The Manitoba Hydro-Electric Board. This three system interconnection embraces a vast area. Three time zones are involved and this fact emphasizes the very real advantage of capacity sharing or availability during the time-displaced load peaks.

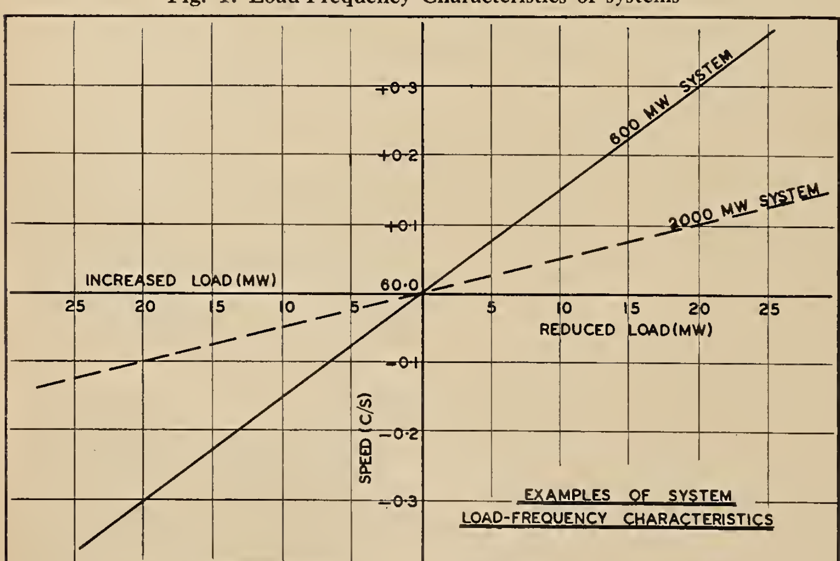
The current-1960 generating capabilities of the S.P.C., M.H.E.B. (including The City of Winnipeg Hydro-Electric System) and the Northwestern Region of the H.E.P.C.O. are approximately 500, 850 and 600 mw. respectively. The first interconnection results now in a combined system capacity of some 1450 mw. and broadly speaking could improve regulation proportionately to the increased capability. By the second interconnection, all three benefit, but especially the S.P.C. which has joined an effective system of nearly three times its own capacity with the corresponding advantages.

By taking liberties in detail to illustrate the principle of the point we are able to represent the load-frequency characteristics of a system by the straight line relationship in Fig. 1[1]. For the example shown, the solid curve could represent the characteristic for S.P.C., H.E.P.C.O., or M.H.E.B., taken as a separate isolated system. As 60 c/s is taken as system frequency, excursions from this value are measures of either excesses or deficiencies in generation. Points on the load-frequency curve of a member system could be obtained by dividing that system into two parts with only a single tie left for interconnection of the two parts. The tie is then loaded to some pre-arranged value, tripped out and the consequent frequency deviation measured. (This method has been employed to determine the correct value of frequency bias for a system.) Fig. 1. then places frequency deviation (usually from 60 c/s) in the ordinate and load deviation, the normally independent variable, in the abscissa.

Fig. 1. also suggests the reduced slope obtained by the double interconnection, i.e. a system of some 2000 mw. Singly, then, the member companies could expect a one-tenth cycle deviation for a 6 or 7 mw. load change. The combined system suggests something like a 20 mw. change would be required before a frequency deviation of one-tenth cycle would occur.

Unfortunately, the simple joining of the member systems by tie-lines does not in itself realize the previously noted advantages. Regulation of tie-line flows is mandatory both for normal operating conditions and during times of unscheduled and unforeseen disturbances in any one of the interconnected systems that may result in tie-line flow fluctuations. Because manual control could never effectively supply the necessary rapid corrective measures, control systems continuously operating upon devia-

Fig. 1. Load-Frequency Characteristics of systems



tions from preset values of tie-line load, system frequency, or both, have been evolved to provide the necessary regulation.

When the H.E.P.C.O.-M.H.E.B. tie-line was completed, load and frequency control equipment was installed for the Manitoba end at the Seven Sisters hydro-electric generating station some 60 miles east of the City of Winnipeg at the western terminus of the interconnecting tie-line. At this time, system dispatching was carried out largely at Seven Sisters so the newly installed load and frequency control equipment found itself conveniently located.

Control Equipment

With the centralizing of system dispatching on the Manitoba System in the new head office building of the M.H.E.B. in Winnipeg, together with the advent of the second tie-line, in this case with the S.P.C., suitable control equipment was required for the new dispatch office. This included the various recording, measuring, scheduling, annunciating and telemetering equipment. The greater part of the generator control equipment originally purchased for the H.E.P.C.O.-M.H.E.B. tie-line functions in the same way but now with operation based upon information from two tie-lines telemetered from the Load Dispatch Office.

The general arrangement is shown schematically in Fig. 2. The S.P.C. and H.E.P.C.O. tie-lines are metered at the Brandon and Seven Sisters Generating Stations of the M.H.E.B. respectively. From these points, the megawatt flow is telemetered to both concerned parties.

At Seven Sisters the quantity is metered and telemetered separately for each participant because of the dissimilarity of the H.E.P.C.O. and M.H.E.B. telemeter systems. Both are, however, of the high speed (0-90% full scale in 1 sec.) frequency type modulating two (main and standby) frequency-shift power-line carriers for the H.E.P.C.O. and two (main and standby) amplitude-modulated tones for microwave radio transmission, for the M.H.E.B.

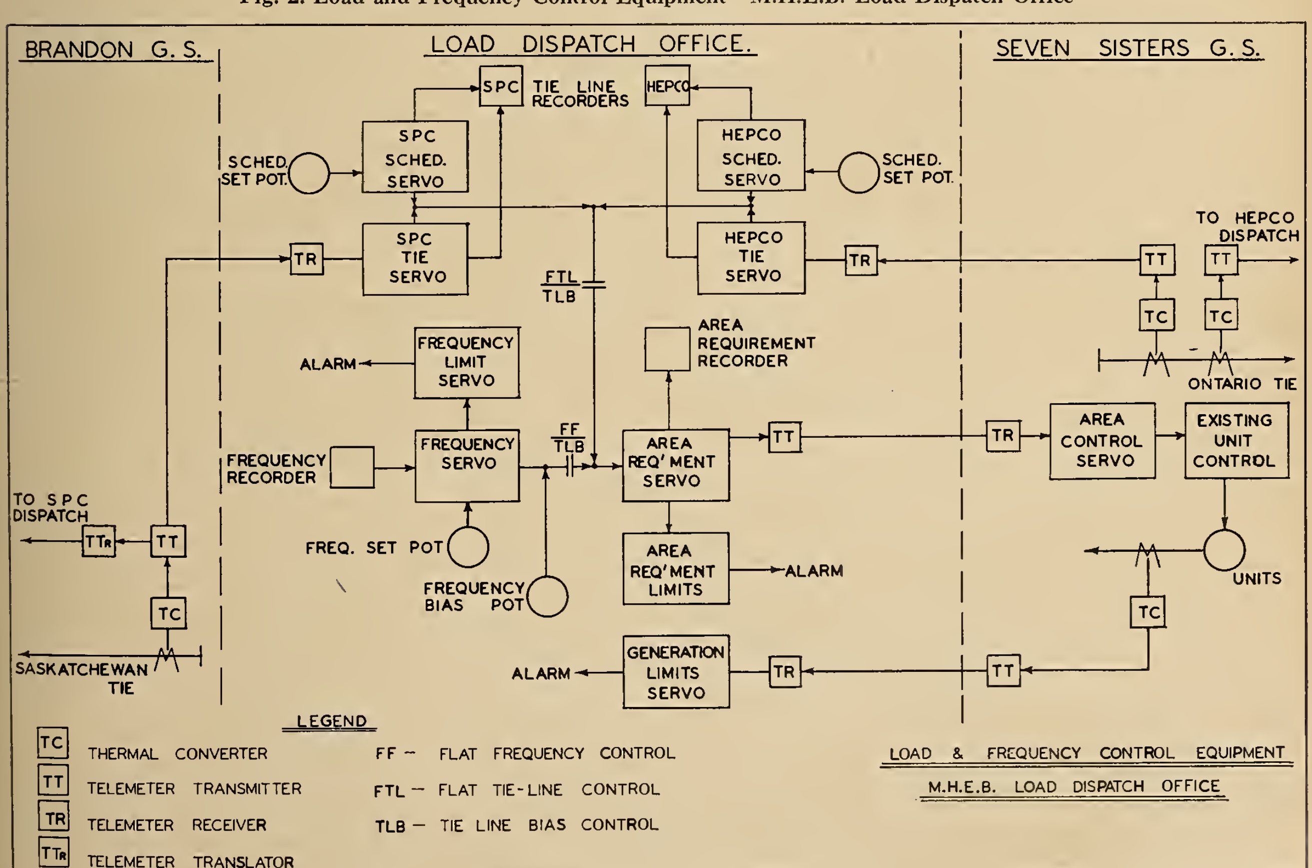
Brandon

At Brandon, a single thermal convertor-telemeter transmitter arrangement is employed to modulate powerline carrier voice-frequency, frequency-shift equipment in both directions. Due to the fact that the S.P.C. telemeter system could be made to operate in the range 7.5-17.5 impulses per sec. and the M.H.E.B. system operates at 15-35 cycles per sec., a simple frequency-halver (telemeter translator) equipped with relay output, was constructed to be driven by the 15-35 cycle unit. This results in both a telemeter cost saving and calibration simplification.

Each of the several M.H.E.B. telemeter receivers convert the variable frequency signals from the transmission channels back into millivolts. These are then tied into the tie-line electronic-bridge servo-mechanisms. A similar signal based upon the position of the schedule set potentiometer positions the schedule servos. The outputs from the tie-line and schedule set retransmitting slidewires are compared. (See Fig. 3). If no signal is produced (the two slides at the same potential), the tie-line flow agrees with the schedule setting and no correction signal is forthcoming. Scheduled flow and tie-line flow are displayed upon two-pen potentiometric electronic recorders for each tie-line.

It will be observed that the schedules can be set individually for each tie-line. This avoids the possible confusion which occurs when net deviation is employed, the operator having to contend with net interchange instead of the actual schedule values. The scheme is readily expandable to cater for new interconnections or for additional ties to existing interconnected systems. The error signals from the two tie-line systems are then algebraically combined before being fed into the area requirement servo, thus automatically

Fig. 2. Load and Frequency Control Equipment—M.H.E.B. Load Dispatch Office



providing the overall error correction.

Frequency Error

In a similar fashion to the above, frequency error is measured by comparing the frequency set point value to that actually appearing on the system. The resultant error signal is combined with that of the tie line resultant flow error before being passed on into the area requirement servo. The frequency error signal may be modified or 'biased' by the setting of the frequency bias potentiometer which is necessary when the tie-line bias mode of operation of the load and frequency control equipment is employed.

The combined error signal then is passed to the area requirement servo which interprets the error signal and decides whether the M.H.E.B. area is deficient in or has excess of generation and passes the correcting signal along (via high speed frequency telemeters) to the control equipment at Seven Sisters which provides the necessary 'raise' or 'lower' signals to the governor synchronizing motors of the generator units under control. Adjustable 'high' and 'low' limit alarms fed from a retransmitting slidewire of the area requirement servo and an area requirement potentiometric recorder are provided. A return telemeter circuit measuring the output of the units under control verifies at any moment that the control action defined at the Area Requirement Servo is in fact being carried out.

Four 27 mw. hydraulic turbine driven generators are under control at Seven Sisters at the present time. All, one or any combination may be placed on control. One unit (any one of the four) is selected as the so called 'master' unit, while the others are allocated their share by load dividing equipment, in proportion to the master unit resulting in an equal distribution at all times.

As the dispatch office equipment has been built up of simple, straightforward components, the later addition of Time-of-Start and Rate-of-Change controls to the schedule servos to permit automatic and smooth loading of the tie-lines will be a relatively simple matter. Likewise, Proportional (Fringe) and Reset (Sustained) equipment can be added readily to modify the Area Requirement output signal. The reset control sets the rate at which the control will correct a permanent or sustained load change. The Proportional control determines the portion of Area Requirement to be corrected immediately by control action, i.e. load changes of short duration.

The three classic methods of control—Flat-Frequency (FF), Flat Tie-Line (FTL), and Tie-Line Bias (TLB) are available. Many excellent papers[1-5] have been written on the principles, techniques, advantages and disadvantages, etc., so they will not be dwelt upon in detail here. It will be observed in Fig. 2 that when, for example, the Flat-Frequency mode is desired, action to the machines under control will be implemented only when deviations from the frequency set point appear, the tie-line servo equipment being switched out. Likewise, when Flat Tie-Line operation is desired, the frequency servo equipment is rendered ineffectual and tie-line flows or rather the deviations therefrom become the controlling quantity. Tie-Line Bias operation makes use of both tie-line flow and frequency information.

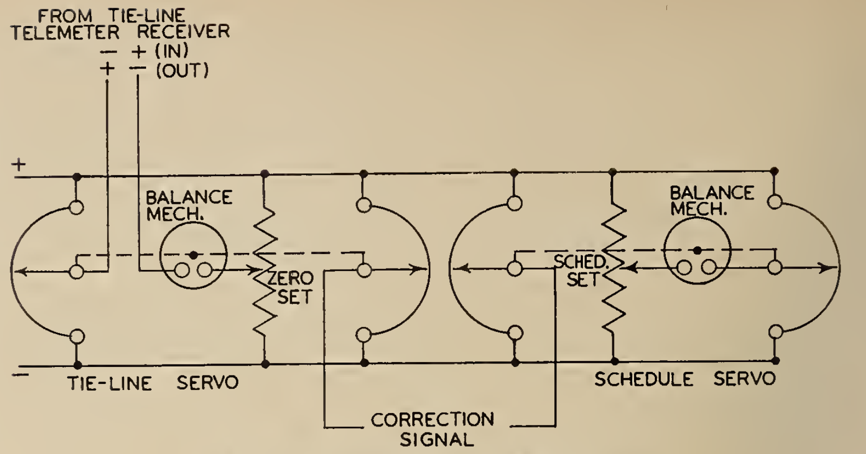


Fig. 3. Tie-Line Flow and Schedule Servos

It will be obvious that if Flat-Frequency operation were to be applied at both ends of a tie-line, schedules could never be maintained. Likewise, Flat Tie-Line at both ends would result in chaotic system frequencies and consequent time errors. One member operating on Flat Tie-Line and the other on Flat Frequency is a workable and often satisfactory mode of operation. Tie-Line Bias operation at both ends has much to offer, at least theoretically, and has found favour in many interconnections.

A system operating on tie-line bias control, at the correct value of bias, would immediately identify whether a load change on the interconnected system had taken place in its own area or not. If not in its own area, it would refrain from any attempt to restore either tie-line or frequency to normal. Any change at this time would only have to be undone later as each area is responsible for satisfying its own load changes and it has been stated that the change occurred in another area. If the load change in the other area had been a sudden increase, the unaffected tie-line bias area, say with a power-frequency characteristic similar to that shown in Fig. 1. would contribute about 7 mw. per .1 cycle deviation (also the correct bias value for this area) which would be its contribution to restoring system conditions. The result is both smooth and direct. If the load increase had been in the area in question operating on tie-line bias, the controls would have immediately called for a raise in output from the units under control.

Flat Tie-Line and Flat-Frequency characteristics are the limiting (maximum bias and zero bias respectively) values of the Tie-Line Bias characteristic. It can therefore be concluded that even an incorrect bias setting offers a more desirable regulating action than a combination of Flat-Frequency-Flat Tie-Line.

The very real advantage in bias operation throughout an interconnection is that no single station or area acts as the master frequency controller and that each area responds and provides for its own load changes. Hence an area operating with controlled machines with different response speeds to those in another area poses no problem under tie-line bias operation. As the Northwestern Region of The H.E.P.C.O. is 100% equipped with hydraulic machines; the M.H.E.B. 67% hydraulic; and the S.P.C. 100% thermal, tie-line bias will receive very close attention.

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Discussion

BUSINESS TRAINING FOR PROFESSIONAL ENGINEERS

R. J. Bedard,
Former Editor of "Genie Construction". The Engineering Journal, November, 1959, p. 75.

Further discussion by B. M. M. Carpendale (The author replied in our February issue to earlier discussion.)

I find myself agreeing heartily with most of Mr. Bedard's remarks, but still in disagreement with his proposal.

To begin with, I do not agree that the mode of application of the methods of science is in any way different whether the problem involve men or machines; the snag is that the methods must be used correctly and thoroughly, and this means stating goals clearly, stating the problem clearly, (and correctly), and taking *all* factors into account. This, of course, includes human factors.

The engineers who to our shame (as Mr. Bedard says) have been responsible for much industrial discord made two main mistakes:

1. They looked at the human being as an inefficient machine instead of an entirely different type of productive resource. Man is less effective at doing most of the things a machine can do, but he has capabilities which a machine has not, and these were not employed;

2. They did not take a broad enough view when assessing efficiency, and only took immediately obvious costs into account.

Possibly these shortcomings could have been put right by the engineering schools, but not many of them understood the trouble themselves.

In the second place, I personally am not hostile to the idea of inculcating "leadership" in an engineering school, (if it is possible at all). By "leadership" I assume Mr. Bedard to mean the responsible attitude of the officer (or the "true aristocrat") towards those in his charge, together with an idea of the processes involved and the pitfalls which lie in wait for those who have to try to get things done through people. This is all that could be aimed for; the divine spark which animates a Napoleon cannot be produced to order. However, there are three main difficulties in attempting to generate even a degree of competence in leadership:

1. At present we have submitted to various pressures and so filled our timetables with technical matter that a major change in policy would be needed to give enough time to this "subject" in undergraduate years;

2. It would be an equally great change in policy for us to accept that it was our job to undertake it at any level. Hitherto we have felt that this sort of attitude and knowledge is needed by all leaders in our society, and not just for engineers;

3. What should we teach? In management there is on the one hand a mass of not very exciting or profound knowledge and technique, given in the many text books on the subject. This is what is taught in most schools of management. It is quite suitable for home study, and we do not feel it should take up undergraduate time at a university. On the other hand, for would-be leaders, there are:

i. The attitude of enterprise and responsibility as glorified by Kipling and Miss Ayn Rand (Atlas Shrugged) and

ii. The type of thinking portrayed by writers such as Peter Drucker and Chester Barnard.

As to the attitudes, these are aimed at in certain sorts of schools, by matters neither obvious nor direct, and also ideally in office training. I have never heard of this being attempted by a university, although this is probably not a good reason for not trying. A better reason might be that university training has been traditionally concerned with the brain (or mind?) rather than with attitudes and emotions.

The "thinking" concerned is very much the business of a university but at a graduate level. Although it is not too difficult for undergraduates, it requires too much background knowledge (of a non-university type) to attempt, in an already crowded undergraduate course, to more than suggest some patterns of thought. As a graduate course it seems to be a duplication to compete with management schools.

Is Mr. Bedard really making the point that Universities are producing the leaders of the nation and therefore should give training in leadership? This will involve a great deal more than the knowledge acquired in a school of management.

HIGHWAYS RESEARCH ACTIVITIES IN CANADA

Gordon D. Campbell, M.E.I.C.
Director of Technical Services, Canadian Good Roads Association, Ottawa, Ontario
The Engineering Journal, December 1959, P. 43.

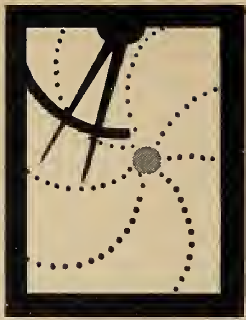
Discussion by G. G. Meyerhof, M.E.I.C.

This interesting paper is very timely because of the great expansion of Canadian highways now in progress. The importance of this subject can be seen from the fact that over 15% of the total expenditure on construction in Canada is in the field of highway engineering, which now exceeds the sum of one billion dollars per year. As the author points out, the outlay of only one-tenth of 1% of this sum for the purpose of research on highway problems in Canada is indeed a very modest investment when the great benefits of this work are considered. In this respect it is of interest to note, however, that the same amount of one-tenth of 1% for research holds also in the other branches of civil engineering activities in Canada.

The author's plea for more highway research in this country should be heartily endorsed. While *basic* research in this field (i.e. long-term research in the fundamental scientific principles) carried out in other countries could indeed be applied in Canada, the results of *applied* re-

(Continued on page 112)

Automation and Control Engineering in Canada



THE VERY diversified fields in which the instrument engineer may expect to operate were indicated quite extensively at the recent symposium on instrumental methods of analysis (Instrument Society of America) held in Montreal.

The program was international in scope and dealt with current practice in Europe and the United Kingdom, though most of the contributors to the technical sessions were from Canada and the United States. Most of the papers were preprinted*, but circulation was limited, and it may be of interest to summarize the main fields in which contributions came from Canadian sources.

The main divisions of the program, in addition to a general session, were: biomedical instrumentation; gas chromatography; spectrographic methods of analysis; electrochemical methods of analysis; physical and chemical methods of analysis; sampling systems; and nuclear instrumentation.

In addition to medicine and nuclear energy, the petroleum and chemical processing industries were prominently represented, but there were also contributions concerning the pulp and paper, metallurgical, textile, and other industries.

General

A wide field was covered by Prof. G. L. d'Ombrain, McGill University, Dr. W. H. Gauvin, Pulp and Paper Research Institute of Canada, and Dr. Leo Marion, National Research Council. More specifically, N. Safran, Provincial Institute of Technology and Art, Calgary, described the industrial laboratory course given at the Institute, and mentioned particularly the training of technicians in instrumental methods of analysis. This is of special local importance, because of the large petroleum and petro-chemical industry, but the subject of training instrument technicians is of very general concern. Dr. F. A. L. Anet, University of Ottawa, described the main principles of nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR), which are new forms of spectroscopy in the frequency region corresponding to radio and microwaves. High-resolution NMR is becoming nearly as important as UV and IR spectroscopy.

Biomedical Instrumentation

In the field of medicine, Canadian contributors described several developments. One of these is a transformer-coupled capacitance-resistance bridge for measuring the dielectric properties of human blood at 100 kc./sec. A technique for investigating the human heart in action involves the injection of radio-opaque dyes in conjunction with dynamic radiographic recording techniques. A problem was to synchronize the injection of dye to the heart beat; this was solved after investigation of many methods, such as applications of the electrocardiogram or pressure changes outside or inside an artery, by obtaining a signal periodic with the cardiac rate from a light source and photo conductive cell arrangement that senses the variation in blood flow through the lobe of the ear.

Neurophysiologists are greatly interested in the time pattern of pulses from a living brain cell, which represent individual discharges or depolarizations of the neuronal unit. A new statistical data processing system, consisting of a simple digital computer with associated input and output devices, has been devised to act as a frequency distribution analyzer and as an event correlator, with ability to extract and display instantaneously complex time relationships between the electrical impulses.

Continuous recording of eye movements, and what the eye sees, is carried out by two television cameras: one views the scene, the other follows eye movements by means of a light reflection from the cornea. The two outputs are combined to show, on a cathode ray tube, the scene with a superimposed spot of light that shows where the eye is looking. A matrix of photocells on the monitor tube can note the various points of fixation of the light spot, and the photocell output can be used to operate various circuits. The successive eye fixations can be recorded on punched tape, and subsequently analyzed by computer or used for automatic control of stimuli. Gating and coding circuits are used for the recording. The photocell output fires the first of six 22-millisec. one-shot square-wave multivibrators connected in series, so that the falling phase of each square wave triggers the next multivibrator in the chain. The outputs of the multivator are connected in parallel, and each photocell both triggers the cascade and operates coded-gating circuits, so that the final output signal is in the teletype seven-element code. These signals are recorded on a teletype printer-perforator so that each eye fixation is represented by a symbol.

Gas Chromatography

The field of gas chromatography is of particular importance to the process industries, and is one of the most rapidly-developing techniques. Great interest was shown in the technical session and in a panel discussion of the subject, which is too involved to deal with in detail here.

Spectrographic Analysis

Heavy water is an expensive material, and it is important to detect contamination entering a heavy water system or loss from it. An instrument has been designed to analyze liquids by automatically measuring their infra-red absorption at three or more wavelengths. Specifically, it is used to monitor the isotopic purity of heavy water, but it can be used to

*Proceedings, 1960 Symposium on Instrumental Methods of Analysis, Montreal, 1-3 June 1960 (sponsored by Montreal Section, Instrument Society of America.)

detect changes in deuterium content of ordinary water or to monitor the heavy water content of the air.

In the field of data processing for infra-red spectroscopy, an analogue computer was described which will: plot spectra of any required size; convert %-transmittance signal from spectrometer to absorbance units; integrate absorption bands.

A problem of general concern is the determination and identification of polycyclic aromatic compounds in the atmosphere, since many of these materials are highly carcinogenic. Paper chromatography is used to separate traces of the materials obtained from air samples, and the problem of identification and estimation is solved by using highly-sensitive physical measurement of the different characteristic ultra-violet fluorescence spectra.

The application of gamma-ray scintillation spectrometry to nuclear reactor technology was discussed, with a description of the useful NaI(Tl) spectrometer. Such instruments are based on a combination of a scintillator and photomultiplier with a pulse-height analyzer.

A more general industrial application described was the control of composition of all alloys produced at a major plant in the aluminum industry by means of direct-reading spectrographs. The methods, using both light emission and X-ray emission instruments, are being extended to the production of non-metallic materials such as alumina. Automation and control systems are used to handle large numbers of samples.

Difficulties experienced with scanning mechanism for a densitometer used in chromatographic work led to the development of an economical and reliable recording instrument, using a standard densitometer, a strip chart recorder, light source, and photo cell. The strip chromatogram is attached to the paper chart of a strip recorder with cellulose tape; the chart thus moves the strip which is scanned by a suitably mounted photometer.

Electrochemical Analysis

It was pointed out that electrochemical methods of analysis are not basically new, since they have been used since the days of of Faraday. However, there are many new developments in the field. A good general review of techniques was presented, as were specific applications.

The pulp and paper industry is one of the widest users of continuous pH (and ORP). The extent of such applications was investigated by means of a questionnaire directed to over a hundred paper companies in the United States and Canada, and the results of this survey were presented. Much valuable information was gathered.

The natural gas industry, now very important in Canada, has quite a problem with the control of sulphur in gas to specified limits. An analyzer has been developed which is based on amperometric titration. Sulphur compounds are determined by reactions involving free bromine or iodine liberated by electrolysis of inert salts as long as the reaction proceeds. The generation currents are a measure of the halogen released, and hence the sulphur contents may be found.

Two types of polarographic instruments have been developed for use in metallurgical plants to help control purity of zinc electrolyte. Two voltages are applied alternatively to the electrodes of the instruments; the difference in electrode current at these two voltages is measured, and the instruments calibrated for concentration in terms of current difference.

Also in the field of metallurgy, a simple method has been developed for determining relative saturation of air in alkaline solutions used in processing uranium and gold ores. It is based on the diffusion current produced by oxygen from the dissolved air when a sample of the solution is subjected to a controlled potential applied to a calomel electrode and a platinum cathode.

Nuclear Instrumentation

Several of the papers on nuclear instrumentation were presented by Canadian authors. A nuclear reactor program requires a lot of chemical analyses, and a description was given of several examples of instrumental methods used. These included emission spectrography, X-ray fluorescence spectrography, flame photometry, Polarography, and chromatography.

Canada concentrates on the heavy-water-moderated nuclear reactor fuelled with natural uranium for economical nuclear power production. Solid and gas mass spectrometry are used in investigations of nuclear changes in the fuel which affect various operating conditions. Also of concern is the need for accurate trace analysis, for which nuclear and mechanical instrumentation has been developed to detect alpha, beta, and gamma emitters.

The use of nuclear techniques by the oil industry has led to developments within the industry. One Canadian company has designed a simple liquid scintillation counter to measure radioactive carbon and tritium. The instrument uses sensitive discriminators to eliminate the need for linear amplifiers. Though the subject presented at the session was the technical design and operation of the instrument, it is noted that this was used in a program of tracing water-flood in an oilfield by radio-trace methods.

Physical and Chemical Analysis

Quite a wide field of instrumentation was covered in the session on physical and chemical methods of analysis. Among Canadian applications were the methods of control used in the advanced effluent treatment plant of an oil refinery. This is a biological oxidation plant with chemical flocculation and ozone treatment. Automatic samplers are required to provide samples for laboratory control on a 24-hour schedule, because of wide variations in the waste. Several of the instruments used in this control system were described.

For the pulp and paper industry, a portable electronic brightness meter of the sphere photometer type was described. This has two calibration points which have to be adjusted only daily, and operates on the pull principle, with an a.c. V.T.V.M. as an indicator. Pulp and paper brightness is measured with accuracy of ±0.3%. A calibrated potentiometer serves as a read-out device.

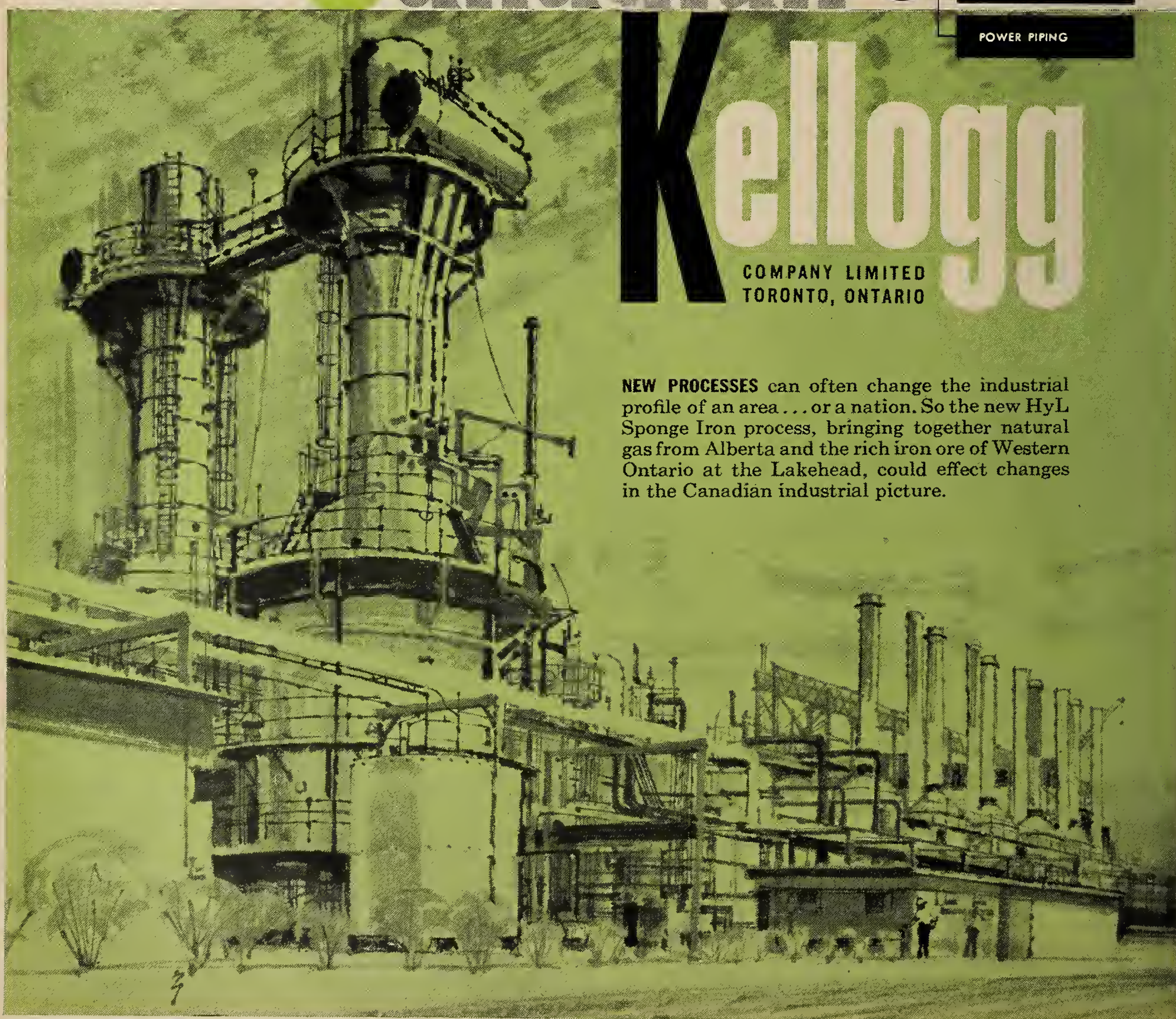
Sampling Systems

The practical value of an analyzer depends on the provision to it of the right sample, in the right form, and many cases of difficulty with process analyzers can be traced to incorrect sampling systems. With complicated processes one may have to invest a higher than usual proportion of capital in a well-designed sampling system if the full benefits of analysis are to be realized. The papers in this session discussed in some detail the various considerations of this nature and some of the snags that are met in field assembly or in specification of sampling systems.

Conclusion

The Canadian contributions to this symposium have been outlined very briefly. The many contributions from the United States and Europe were of equal interest to the instrument engineer.

We are indebted to G. B. Hall of Canadian Industries Limited for the article "Corrosion Problems in Chemical Plant Instrumentation" which appeared in our May issue.



Canadian Developments

Northumberland Strait Crossing Feasibility Study

The problem of spanning Northumberland Strait, nine miles of water subject to considerable tidal variation and severe icing in winter, has been on the minds of engineers since 1891. Recently Major-General H. A. Young, M.E.I.C., Deputy Minister of Public Works, Charlottetown, P.E.I., made public a progress report on feasibility studies for the Northumberland Strait Crossing, including proposed location and alternative designs as well as information on weather and tide conditions.

Construction of such a causeway or bridge would represent a unique accomplishment. The Canso causeway, to take just one example of similar existing structures, is only one eighteenth of the length of the proposed Northumberland crossing. Since March, 1958, the Federal Government has spent almost $600 thousand on this investigation and has called on the Department of Mines and Technical Surveys' Hydrographic Services; the Department of Public Works; and the National Research Council. Should such a project be undertaken, it would involve the Departments of Transport and Fisheries as well as those already mentioned and the Canadian National Railways.

A completely closed causeway would affect the high and low water levels of the Strait and the range of tide in the principal harbours. It would also have substantial effects on short line conditions. Indemnity would have to be paid for land actually flooded and cottages made inaccessible. The total estimate of indemnity is close to $3 million. Remedial works to harbours and channels would call for another $12.5 million. It is believed that a quasi-stationary strip of ice would form to either side of the causeway early in the winter, thus protecting the structure from fast moving ice floes, however the problem of freezing sea spray on the causeway in the early winter months would have to be dealt with.

Borings have been made in the main quarry site and alternate quarry sites on P.E.I.; on two possible lines of crossing to investigate foundation conditions; and on possible lock positions and channel approaches. A test quarry has also been opened in the Bayfield area of N.B. to test for core and armour stone, both of which have been found to exist in sufficient quantity.

The proposed location of such a crossing is a straight line between Jourimain Island and Borden Point, based on minimum fill requirements, availability of fill, good sea bed conditions, and existing road and rail facilities in the vicinity.

The causeway design calls for a crest width of 80 ft. for highway and rail traffic, with a rock-fill constructed to an elevation of minus 20 Canadian Geodetic Datum to form a sill. Causeway slopes would be protected by a layer of armour stone, the 3 to 6 ton blocks placed in layers by cranes to interlock to the greatest extent possible. The design includes one major navigation lock and a secondary lock for small crafts.

A bridge crossing would have the obvious advantage of maintaining present tidal conditions. It would be built to a length of 37,280 ft. and would provide a two-lane highway and single railway. A high level section of 960 ft. would provide a 150 ft. clearance in the central 400 ft. A combined bridge and causeway has also been proposed, with the knowledge that the Strait could be reduced 20 to 25% without increasing high tides very much. In this case, the bridge section would be 6400 ft. Locks would be required to the same degree as for a full causeway.

Quebec Construction Prospects Outlined by CCA President

The 1960 construction program is expected to reach $1,777 million, or nearly one quarter of the Canadian total of $7,317 million, according to Jack M. Soules, president of the Canadian Construction Association. The program breaks down into three roughly equal categories — housing, other buildings, and engineering projects. Housing will be below last year's volume notwithstanding a sizeable carryover of dwelling units being built at the beginning of the year. However, commercial, industrial and institutional construction is expected to increase in volume in 1960, despite completion of seaway projects.

Canadian Space Research

The National Research Council reports that Canada's interest in space research at the present time is purely scientific and that her central preoccupation is with the outer fringes of the earth's atmosphere and neighbouring regions. The International Geophysical Year rocket studies, in which Fort Churchill was involved, established that the density at higher altitudes is much greater than had been thought. This supports the idea that the earth's atmosphere merges with the sun's and never descends to pressures approaching those of interstellar space.

More than 100 rockets were launched from Port Churchill during the Geophysical Year and the latter part of 1959, four of which were instrumented by Canadian scientists. A joint U.S.-Canadian program is continuing there, mainly for the study of cosmic rays, the ionosphere, the aurora, and the physical and chemical properties of the Upper Atomosphere. Canadians are using their own rockets, and a committee under the direction of Dr. D. C. Rose, head of NRC's cosmic rays section, will coordinate the investigations.

Canada is not making space probes of her own, but she will participate in the activities of the Committee on Space Research, of which both the U.S. and the U.S.S.R. are members, and the United Nations Committee on the Peaceful Uses of Outer Space.

Professional Engineer on College of Medicine Faculty

The University of Saskatchewan has appointed a professional engineer to the faculty of the College of Medicine as a result of very productive research in the field of medicine carried out through cooperation between the College of Medicine and the College of Engineering at the university.

Blaine A. Holmlund, lecturer in electrical engineering, will also become lecturer in biomedical engineering in the Department of Medicine. Some of the products of this combined research at the University of Saskatchewan are: a method to record instantaneously the time taken for blood to circulate between the carotid artery in the neck and a variety of points in the brain; the use of the heart-lung machine in "open heart" surgery with an automatic control system which replenishes the reservoir of blood in the machine precisely as needed; and an improved method of determining the tensile strength of delicate sutures used in eye surgery.

International News

New Space Academy

An International Academy of Astronautics, to provide world technical leadership for the peaceful conquering of space and to serve as a clearing house for astronautic information, has recently been established by the International Astronautical Federation and the Daniel and Florence Guggenheim Foundation.

Dr. Theodore von Karman, dean of American astronautical scientists and chairman of the Founding Committee authorized to establish the Academy at last year's London meeting of the Federation, has said that the association will provide "what may be the only intellectual meeting ground" for the scientists and engineers of all nations, East and West.

In his statement announcing the grant for the new association, Harry F. Guggenheim, President of the Daniel and Florence Guggenheim Foundation, said that the Foundation's support of the Academy resulted from its long history of interest in aeronautics. In addition to its Goddard rocket research projects, the Foundation supports research centres in jet propulsion at Princeton University and the California Institute of Technology, an Aviation Safety Centre at Cornell University, an Institute of Flight Structures at Columbia University, a Centre of Aviation Health and Safety at Harvard University, and provides a number of fellowships in the Flight Sciences.

Among the distinguished initial members is Professor John Cobb Cooper of McGill University, General Counsel of the International Air Transport Association; Dr. A. C. B. Lovell, Director, Jodrell Bank Experimental Station, England; Dr. J. A. Van Allen, of the State University of Iowa, discoverer of the Van Allen radiation belts around the earth; Professor J. Ackeret of the Institute of Technology, Zurich, world-famous aerodynamicist; and Professor A. N. Nesmeyanov, President of the U.S.S.R. Academy of Sciences.

It is expected that the Academy will be made an active concern at the Stockholm meeting of the International Astronautical Federation in August and that permanent headquarters will be in Paris.

Highway Construction in the Sahara

French engineers and chemists working on the problem of extensive road construction in the desert have made notable progress. Soil stabilization with sodium lignosulphite and other chemical compounds has been carried out successfully. The moistureless soil of the Sahara treated with limited quantities of water and relative portions of the stabilizing compound becomes solid and water-tight. Some of the local gypsum is also used as a stabilizing agent.

In order to get the necessary water for road construction, wells have been drilled to depths of from 330 to 4,000 feet. Chemicals have been brought in by air, and construction sites have been planned on high output basis, in order to make the operation economically feasible.

Whereas up to 1955 a simple road network of 6,200 miles was sufficient, only 300 miles of which were surfaced, the discovery of natural gas pockets and oil fields in Hassi-Messaoud and Edjele have necessitated a whole new roads system. By the end of 1960, about 1,100 miles of new road will be completed, and construction is now progressing at the rate of 250 miles per year.

U.K. Motor Vehicle Industry Expansion

The current expansion plans of the UK motor vehicles industry provide for the expenditure of approximately $500 million. A number of companies have agreed, after discussions with the Board of Trade, to locate their new plants in "designated" areas as defined in the Local Employment Act, districts of greater than average unemployment.

The British Motor Corporation will raise its annual output from 750,000 to a million vehicles by the end of 1962 and will establish new factories in Scotland and South Wales. They will produce complete heavy commercial vehicles and tractors in Scotland, and car production will be increased by making the fullest use of the company's existing factories, especially in the Midland and Oxford areas. The Ford Motor Company has agreed with the Board of Trade to build a large integrated motor factory on the outskirts of Liverpool, while Vauxhall and Standard-Triumph are also considering expansion and relocation. According to the agreement, companies building in these special areas will be eligible for government assistance.

American Levacar discussed at ASME meeting

Engineers congregating in Dallas in early June for the American Society of Mechanical Engineers sessions were introduced to the new American levacar, a vehicle which may one day glide from one city to another at 500 m.p.h. on a thin film of compressed air. The car is designed to be mounted on flat-topped tracks similar to railroad tracks. Lifted from the track a fraction of an inch by a steady stream of compressed air against levapads which fit around the track, the frictionless car is propelled by an aircraft engine.

Japanese Prefab Plants for Export

The Japanese industrial machinery industry is now exporting pre-fabricated plants and factories for a wide variety of uses, chiefly to the countries of the Far and Middle East. They include units for the processing of pulp and paper, plastics, cement, sugar, textiles and textile synthetics. The export business ranges from supplying, laying out, and erecting abroad to supplying just a single unit of machinery or group of machines, although about 65% of the industrial machinery export is in plant units.

Swedish Research Reactor

The country's third reactor, the R2, is now in operation at Studsvik on the Baltic Coast, south of Stockholm. The reactor, a materials testing unit, is the largest research reactor in operation in Europe. The $6 million reactor is intended for developing fuels, as well as testing materials, for future large power-producing reactors. Later this summer, R2, which is a modified pool type reactor, will be equipped with a new tank, enabling it to be operated at 30,000 kW. The fuel is about 6 kg. of highly enriched uranium.

Month to Month

HONOURS and AWARDS
ANNOUNCED at WINNIPEG, 1960

Honorary Memberships

The highest form of recognition within the gift of the Institute was bestowed on Bristow Guy Ballard, William Percy Dobson, Richard L. Hearn, Otto Holden and John Norison Finlayson.

Dr. Ballard

Dr. Dobson

Dr. Hearn

Mr. Finlayson

The Julian C. Smith MEDAL

"For achievement in the development of Canada"

Hugh Andrew Young

Clarence Decatur Howe

The LEONARD MEDAL

For papers on mining subjects
Awarded to Victor Dolmage and J. W. Stewart for "The Demolition of Ripple Rock". Mr. Stewart is at left. Mr. Dolmage was represented at the Awards Luncheon by Mr. E. E. Mason.

The PLUMMER MEDAL

For metallurgical subjects
Awarded to J. T. Hugill for his paper, "A Large Capacity Oxygen Plant for Metal Refining".

The ROBERT W. ANGUS MEDAL

Awarded to J. J. Traill for his paper "Tests of Hydraulic Turbines — an Appraisal".

The DUGGAN MEDAL and PRIZE

were won by A. G. Davenport, a member of the Institute and now Research Fellow and Research Assistant, the Department of Civil Engineering, University of Bristol, England. He received the award for his paper "The Wind-induced Vibration of Guyed and Self-supporting Cylindrical Columns".

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on April 30, 1960.

Member: S. I. Ahmed, Montreal; J. M. Bannon, Montreal; A. J. B. Birkmyer, Toronto; J. B. Christensen, Montreal; J. T. Colquhoun, Copper Cliff; K. W. Dollansky, Sherbrooke; B. P. Emo, Toronto; C. L. Erb, Cleveland; S. A. Kazimierowicz, Montreal; G. W. Mitchell, Ottawa, S. Nowski, Toronto; M. M. W. Smith, Vancouver; W. R. Stevenson, Sarnia; B. W. Taylor, Montreal; A. F. Tregenza, Toronto; S. Van Ingen Schenau, Ottawa.

Junior: R. H. Banning, England; A. F. Brodie, Toronto; D. E. Coulter, Toronto; N. Hayward, Niagara Falls; C. R. Keleher, Montreal; T. W-N. Lam, Idaho, USA; S. J. Pellegrini, Peterborough; J. B. Plant, Smith Falls; M. F. Rottman, Toronto.

Affiliate: S. W. Wood, Hamilton.

Junior to Member: D. L. Allen, Atwood, Ill.; C. T. Armstrong, Toronto; J. L. Armstrong, Toronto; J. J. Arnason, Winnipeg; D. T. Austin, Kingston; O. Y. Barde, Montreal; G. F. W. Barrett, Montreal; K. E. Barter, Ottawa; K. O. Bartlett, Fredericton; H. R. Beck, Montreal; G. A. Bernard, Sherbrooke; A. Bernardi, Montreal; G. J. Bialik, Peterborough; A. B. Biggar, Venezuela; J. G. S. Billingsley, Newark, Del.; R. A. Bird, Winnipeg; R. Boisvert, Chicoutimi; L. G. Boivin, Montreal; R. N. Bower, Lethbridge; W. S. Bradbeer, Burlington, Ont.; P. J. Brais, Montreal; S. Bramah, Sudbury; C. G. Brean, Fredericton; J. L. Bremner, Dauphin, Man.; D. W. Briden, North Bay; A. L. Briere, Drummondville; D. N. Brockhurst, Cincinnati; G. Brynildsen, Shawinigan; M. R. Byrne, Hamilton; M. L. Bussiere, Montreal; R. L. Carriere, Montreal; W. L. Cary, Edmonton; W. E. Castellano, Hingham, Mass.; R. R. Cheyne, Br. Guiana; J. A. Choquet, Montreal; P. B. Cleugh, Montreal; D. H. Cohoon, Arvida; G. F. Colford, Montreal; R. C. Cook, Montreal; R. M. Cooper, Montreal; C. P. Corbett, Lucan, Ont.; B. M. Corey, Hamilton; L. J. Cousineau, Montreal; H. J. Cox, Tweed, Ont.; J. P. Dagenais, Montreal; G. R. Decarie, Montreal; A. C. deLery, Montreal; J. Deptuck, Brazil; D. G. C. Donaldson, Ottawa; G. W. Downie, Trail; R. Y. Dubuc, Montreal; I. G. Duncan, Ottawa; A. P. Earle, Montreal; K. R. Ebbern, Winnipeg; G. B. Eccles, Trail; D. R. Ells, Edmonton; W. E. Emmerson, Toronto; T. J. Erskine, Winnipeg; K. J. Fallis, Winnipeg; H. R. Farley, Ottawa; R. P. Fillmore, Fort William; W. M. Flanagan, Toronto; D. M. Foulds, Toronto; S. Gaunt, Montreal; R. J. Gill, Montreal; J. H. Goar, Hamilton; G. Granek, Toronto; T. C. Greenlees, London, Ont.; J. L. Greer, Winnipeg; D. G. Grey, Ottawa; B. J. A. Grondin, Quebec; R. T. Haine, Montreal; E. G. Hale, New Westminster; J. A. Hale, Montreal; R. Halfyard, Mt. Pearl Park, Nfld.; M. A. Hanson, Cornwall; J. L. Harbell, Hamilton; L. E. Hardman, Port Arthur; J. F. Harris, Toronto; J. F. Hewson, Windsor; G. H. Hicks, Vancouver; P. Hobson, Montreal; C. E. Holtby, Montreal; J. W. Howe, Montreal; N. E. Hudak, Toronto; J. P. Huza, Montreal; C. E. Ireland, Winnipeg; D. Johnson, Montreal; R. G. Johnson, Windsor; J. L. Jomini, Grand'Mere; R. E. Jonasson, Peterborough; J. E. Jones, Calgary; L. P. Kenyon, Toronto; M. Kilbertus, Montreal; J. N. Lacroix, Montreal; L. J. Laflamme, Montreal; R. H. Lalande, Noranda; A. E. Lalor, London, Ont.; L. Y. Langlois, Quebec; A. J. J. Laporte, Montreal; L. A. Leeyus, Toronto; P. Lesperance, Montreal; R. J. Lindsay, Montreal; J. D. Logan, Hamilton; J. D. Long, Montreal; B. Y. Lynn, Winnipeg; K. W. Macaw, Winnipeg; A. G. Macdonald, Montreal; N. F. Macfarlane, Montreal; W. R. Macke, Nigeria, Africa; V. G. MacWilliam, Saint John, NB; C. F. Mallory, Montreal; E. V. Malmgren; Winnipeg; G. K. Mantha, Montreal; G. G. Marshall, Winnipeg; H. K. Matthews, Calgary; E. P. McCormack, Montreal; H. O. McCullough, Windsor; C. A. McDonald, Fort Erie; A. McGregor, Winnipeg; J. D. McIlween, Toronto; A. M. McNevan, Montreal; D. A. McRae, Wilmington, Cal.; J. A. McRae, Ottawa; R. L. Mechin, Toronto; S. Meland, Montreal; D. F. Moore, San Francisco; E. A. Moore, Toronto; J. U. Moreau, Three Rivers; J. P. Morgan, Hamilton; B. Moroz, Montreal; W. B. Morrison, Montreal; A. E. Mudge, Fort Erie; T. L. Newell, Montreal; R. K. Nicholson, Montreal; W. H. Nord, Toron-

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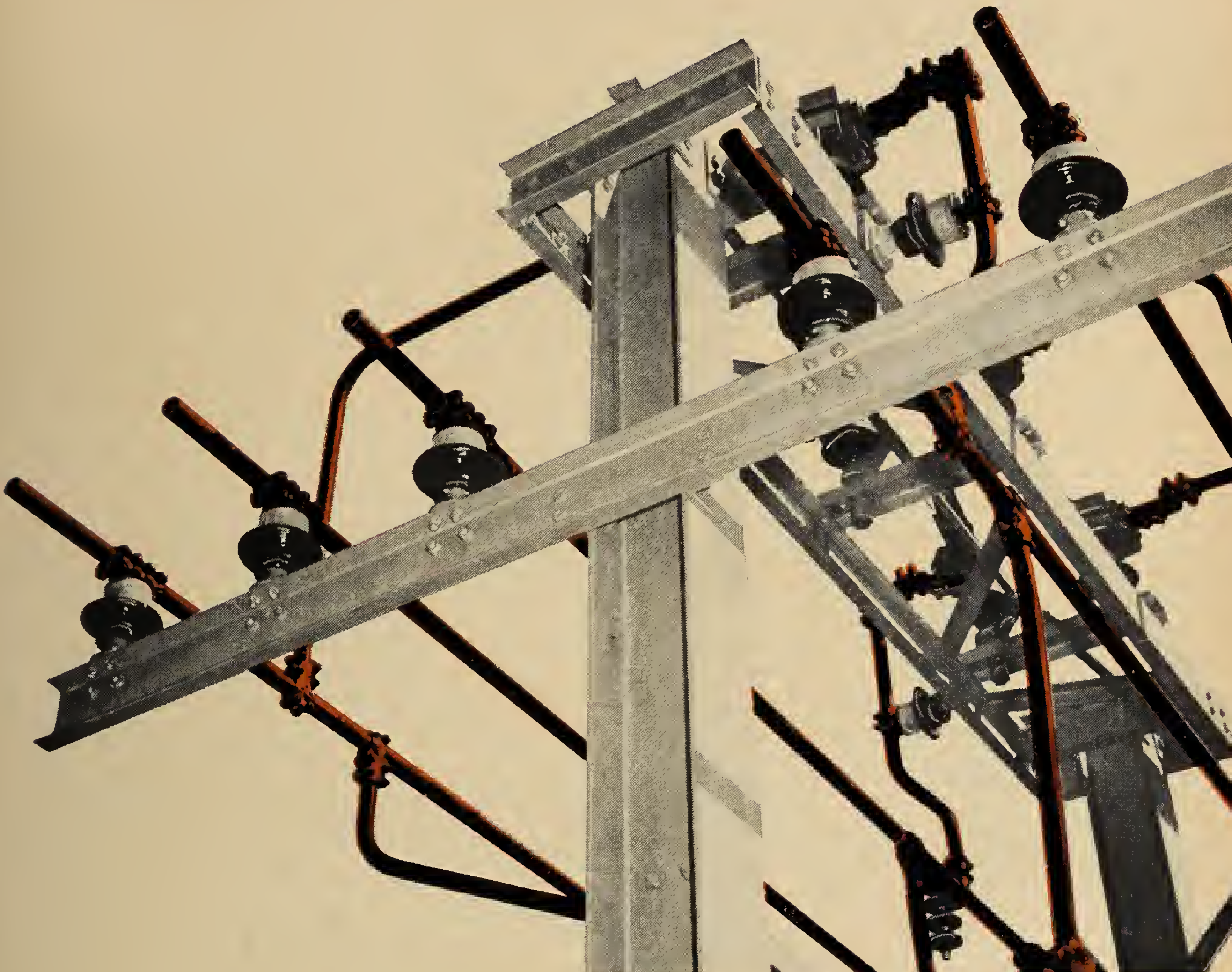

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STUDENTS ADMITTED

Ecole Polytechnique: J. Alepin, L. Asselin, J. Aubin, M. Beaudet, R. C. J. Beaudry, J. M. Beaulac, A. H. Beauregard, A. Beique, G. Belanger, J. M. Belanger, R. Bergeron, M. Bernard, A. Boily, J. Bonin, N. Bouchard, G. Boucher, H. P. Boulianne, J. W. Brillon, J. Brochu, J. Brunelle, L. Caron, Y. Caron, C. Carriere, R. Carriere, P. E. Carrieres, D. Chevrier, C. Chouinard, P. A. Collin, L. Corbeil, R. Cote, S. Dagenais, N. D. Dalpe, G. D'Aoust, J. M. P. Darveau, J. R. De Broux, G. De Paoli, D. Derome, R. Deshaies, M. P. Desrochers, R. Desrochers, M. Dessureault, P. de Varennes, G. Deziel, R. Doret, G. Doucet, C. Drouin, M. Drouin, P. Dube, R. Dubois, G. Dufour, P. Dumas, J. Dussault, Y. Favreau, A. Fecteau, J. S. Filiatrault, F. Furstner, M. Galipeau, C. Gaudreault, J. G. Gauthier, C. Gilbert, R. Gingras, F. L. Girard, P. Girard, M. A. Girard, Y. D. Girard, E. Gratton, J. A. G. Gravel, J. Y. Grenier, G. Grise, R. Guillemette, G. J. Halley, A. Hornois, P. E. Hervieux, J. L. Houle, J. P. Huard, J. C. Huot, C. Johnson, K. Kandien, G. Labelle, C. Lacasse, J. Lafontaine, M. Laforest, J. F. Lalande, P. Lalancette, J. Lanthier, D. Laplante, J. L. Laporte, L. Laporte, J. A. R. G. Laroche, R. Laroche, J. Lavigne, G. Leclerc, J. G. Leduc, L. J. M. Lefebvre, P. E. Lefebvre, R. L. Lefebvre, J. C. Legault, L. A. Lehoux, R. Lemieux, A. R. Lemoine, Le Thanh Nhan, G. Leveille, C. Liboiron, C. Lizotte, M. Lussier, J. F. Maillot, M. Y. Mailloux, P. Marcotte, J. R. Maynard, R. Mercier, J. G. R. Methot, J. Monette, B. Morin, R. Normand, C. Ostiguy, R. Page, M. Painchaud, G. Pare, J. L. Pepin, L. M. Pilote, Y. Pau, B. Prevost, M. A. Provost, R. Provost, L. Rainville, C. Raynault, P. Richard, M. Rigaud, L. G. Roberge, S. Roch, M. Rondeau, D. R. Rota, R. Roux, J. Saia, R. Salette, A. Sasson, S. Saulnier, R. Sauve, M. Seidman, Yse Sir, M. G. Tanguay, R. Tetreault, J. G. Tremblay, M. Trottier, G. Trudelle, J. R. Theberge, P. Theberge, G. Thibault, J. G. Vaillant, J. Valade, M. Vallee, Y. Vanier, J. Verdy, J. M. Vezeau, J. G. Villeneuve, G. Voyer, R. Guillemette.

University of Waterloo: G. T. Barker, R. W. Bowes, R. A. Dawson, J. Z. Gazdig, R. E. Hamilton, J. R. Hull, M. J. Hutch, J. Kruuv, P. J. Kurtz, P. A. Martin, W. G. McConnell, H. W. McKibbon, D. L. Messham, L. C. Moss, R. W. Oddson, A. D. Robb, J. Roorda, R. L. Saunders, W. G. Schneider, C. E. Schultz, R. H. Watson.

Acadia University: F. W. Bartle, F. W. Bayer, D. M. Callan, G. E. Cummings, S. F. Galovics, C. W. S. Jarvis, W. E. Kent, M. P. Miller, M. R. Morash, T. B. Nicherson, R. G. Rice, A. R. Sprogis, R. G. Theakston, G. E. Wile.

Mount Allison University: L. H. Chapman, A. E. Cummings, E. J. Dewar, H. W. Duncan, G. N. Henderson, D. E. Hopkins, J. E. Lewis, W. E. Lockerby, M. A. Lodge, M. J. Royea, R. B. Winsor.

Nova Scotia Technical College: A. D. Burden, H. E. Carroll, J. G. J. Gagnon, H. E. R. Ottley, M. J. E. Sheflin, E. J. Snook, R E. Sparkes, S. X. Tzagarakis, A. C. Wells, T. A. Wibowo.

University of Toronto: D. R. M. Jones, K. Patune, W. Pay, R. B. Potter, D. K. Pulfer, P. J. J. Schmidt, W. A. Teasdale, A. E. Virgin, O. R. Wolfgang.

Assumption University: R. A. Lane, H. Lee, P. P. Nuspl, S. J. Nispl, R. J. Rayzak, S. Skorupinski, P. Wei.

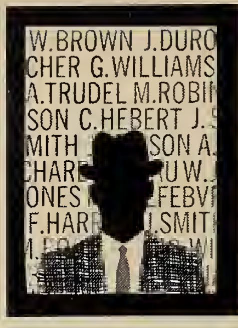
McGill University: J. M. Beck, D. M. Bolduc, R. R. Farmer, M. Rabinovitch, J. E. Samson.

University of New Brunswick: R. J. Bateman, A. D. Fitzgerald, R. D. Weir.

University of British Columbia: T. Negoro, T. A. Tasaka, D. A. Towgood.

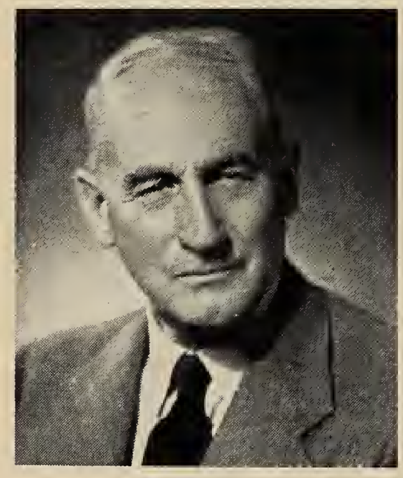
(Continued on page 100)

Personals



The election of **Dr. John Bertram Stirling**, Hon. M.E.I.C. (Queen's, B.A. '09, B.Eng. '11, L.L.D. '51) to the Chancellorship of Queen's University is a very great honour to the Institute of which he has been a member for forty-seven years and whose president he was in 1952-53.

Dr. Stirling, in accepting his new office, joins a distinguished group of engineer chancellors, including Dr. C. J. Mackenzie, a past president of the Institute, of Carleton University; R. E. Powell, of McGill University; and the Rt. Hon. C. D. Howe, of Dalhousie University.



J. B. Stirling
Hon. M.E.I.C.

The eighth chancellor of Queen's University and the second engineer to hold this office (Sir Sanford Fleming was in office from 1880 to 1915), Dr. Stirling is President of E.G.M. Cape and Company, Montreal.

He has been a prominent member of the Queen's alumni, serving in the past as President of the Queen's General Alumni Association, Chairman of the Building Committee and Vice-Chairman of the Board of Trustees. In 1951 the honorary degree of Doctor of Laws was conferred upon him by the university.

His professional leadership has been demonstrated widely over the years in the presidencies of the Engineering Institute of Canada, the Canadian Construction Association (1942-43), the Corporation of Professional Engineers of Quebec (1948-49) and the Montreal Board of Trade (1950).

Dr. Stirling has long been admired in the profession and in public life for the quality and diversity of his accomplishments. A strong advocate of individual initiative, he is indeed a fitting person to take up the duties of Chancellor at Queen's University.

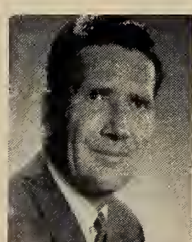
Lawrence MacIsaac, M.E.I.C. (N.S.T.C. '46) has been appointed Industrial Commissioner for the Central Region of the Canadian National Railways at Toronto.

McNeely DuBose, M.E.I.C. (North Carolina State College '12) has been appointed Consultant for Sandwell International Ltd., Power Division. Mr. DuBose is a former executive vice-president of the Aluminum Company of Canada.

J. R. Mills, M.E.I.C., has been elected a director and appointed Vice-President & General Manager of Foundation Maritime Ltd., with headquarters in Halifax.

Yvon Tasse, M.E.I.C. (Ecole Polytechnique '35) has been appointed Parliamentary Secretary to the Minister of Public Works by Prime Minister Diefenbaker.

Y. Tasse
M.E.I.C.

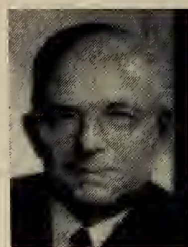


D. C. Jones
M.E.I.C.

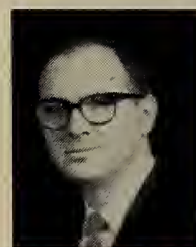
D. Carlton Jones, M.E.I.C. (McGill '34) has been appointed General Manager of the Production Department, Hudson's Bay Oil and Gas Company Limited.

G. R. Adams, M.E.I.C. (Queen's '27) has been appointed Vice-President and General Manager of Foundation Overseas Ltd., a subsidiary of Foundation Company of Canada Ltd.

J. Roy Gordon, AFFILIATE E.I.C., **has been** elected President of the International Nickel Company of Canada Ltd. He is a native of Kingston, Ontario.



J. R. Gordon
AFFILIATE E.I.C.



A. M. Mackay
M.E.I.C.

A. M. Mackay, M.E.I.C. (Toronto '50) has opened a consulting practice at Owen Sound, Ontario, under the name of A. M. Mackay & Associates Limited. The firm will specialize in sewerage, drainage, water, road and structural engineering.

David J. Lewis, M.E.I.C. (Queen's '24) is the new Chief Engineer of the Platework division at the Montreal Branch of the Dominion Bridge Company Ltd.

D. J. Lewis
M.E.I.C.

A. M. Bain
M.E.I.C.

A. Mark Bain, M.E.I.C. (Manitoba '28) has been appointed Assistant to the Director of Engineering at the head office of the Dominion Bridge Company Ltd. in Montreal.

C. N. Simpson, M.E.I.C. (Queen's '40) has been appointed Vice-President and General Manager, Engineering, for H. G. Acres & Company Ltd.

Robert F. McAlpine, M.E.I.C. (N.S.T.C. '28), Vice-President and General Manager of N.S. Tractors & Equipment Ltd., was recently elected 2nd Vice-President of the Canadian Association of Equipment Distributors at its annual meeting in Montreal.

Wide open spaces...

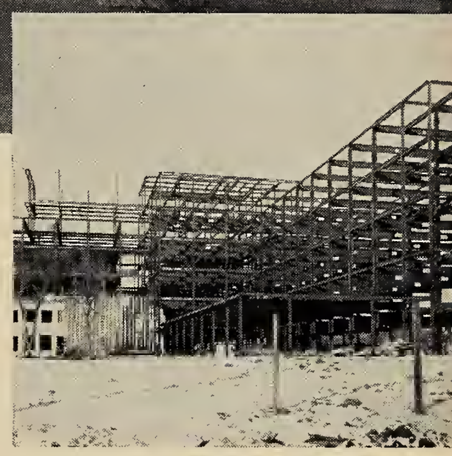
You get space, speed, flexibility and economy with steel construction—all were achieved in the Great West Life Assurance Company's new head office building in Winnipeg.

The use of long span steel beam construction gave large column free areas and allowed maximum flexibility of interior partitioning. Future changes in office and space requirements can be easily accommodated.

In addition, openings in the beam webs provided for passage of electrical, plumbing and heating facilities beneath the floor—without adding to the building's overall height. Every inch saved in height meant significant dollar savings.

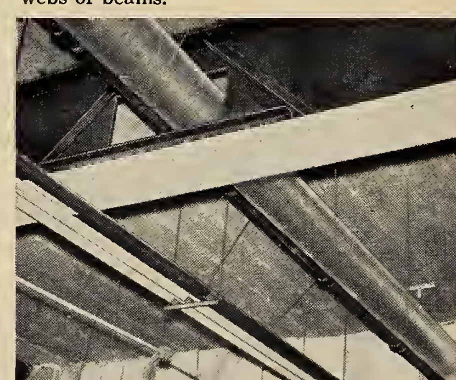
All the steelwork was erected during three months of bitter winter weather. This enabled the sub-trades to move in on time to complete their work.

Architects: Marani & Morris of Toronto and Moody Moore and Partners of Winnipeg. Consulting engineers on structural design: Wallace, Carruthers & Associates of Toronto. Contractor: G. A. Baert Construction Co. Ltd.



1800 tons of steelwork, fabricated and erected by Dominion Bridge, Winnipeg. Most of this was of "rigid frame" design.

Easier and more economical installation of piping was made possible by openings cut in webs of beams.



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structural steel by

DOMINION BRIDGE

FOURTEEN PLANTS—COAST-TO-COAST

E. L. Hartley, M.E.I.C. (Queen's '33) has been elected President of Dominion Structural Steel Ltd., with headquarters in Montreal. Mr. Hartley will remain Vice-President of Western Bridge and Steel Fabricators Ltd., Vancouver.

E. L. Hartley
M.E.I.C.

A. Raymond
M.E.I.C.

A. Raymond, M.E.I.C. (McGill '34), formerly Vice-President and General Manager of the International Braid Company of Canada Ltd. and President of Safeway Heat Elements of Canada Ltd., has opened a new company, Raymond Associates Inc., manufacturers' representatives, Industrial Supplies and Engineering.

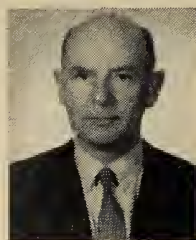
Kent Phillips, M.E.I.C. (Saskatchewan '27) has been elected to a three-year term on the University of Saskatchewan's board of governors. He is General Manager of Evans Construction Company Ltd. and is associated with Kent Phillips and Associates Ltd.

Martin J. J. Dayton, M.E.I.C. (B.C. '49), formerly Senior Assistant Engineer for the Greater Vancouver Water and Sewerage and Drainage Districts, has established a consulting practice in water supply and sewage engineering, in West Vancouver.

D. W. R. McKinley, M.E.I.C. (Toronto '34) has been made Associate Director of the Radio and Electrical Engineering Division of the National Research Council.

W. E. Hickey, M.E.I.C. (N.S.T.C. '38) has been appointed Vice-President and Director of Engineering, The Foundation Company of Canada Ltd., and Executive Vice-President of FENCO.

A. Chmielenski, M.E.I.C. (Warsaw '34) has been appointed a vice-president of Foundation of Canada Engineering Corporation Ltd.



A. Chmielenski
M.E.I.C.

D. W. Hawes
JR.E.I.C.

D. W. Hawes, JR.E.I.C. (McGill '50) has been appointed Chief Engineer of Power Corporation Designers and Consultants Ltd., Montreal.

A. E. Insley
JR.E.I.C.

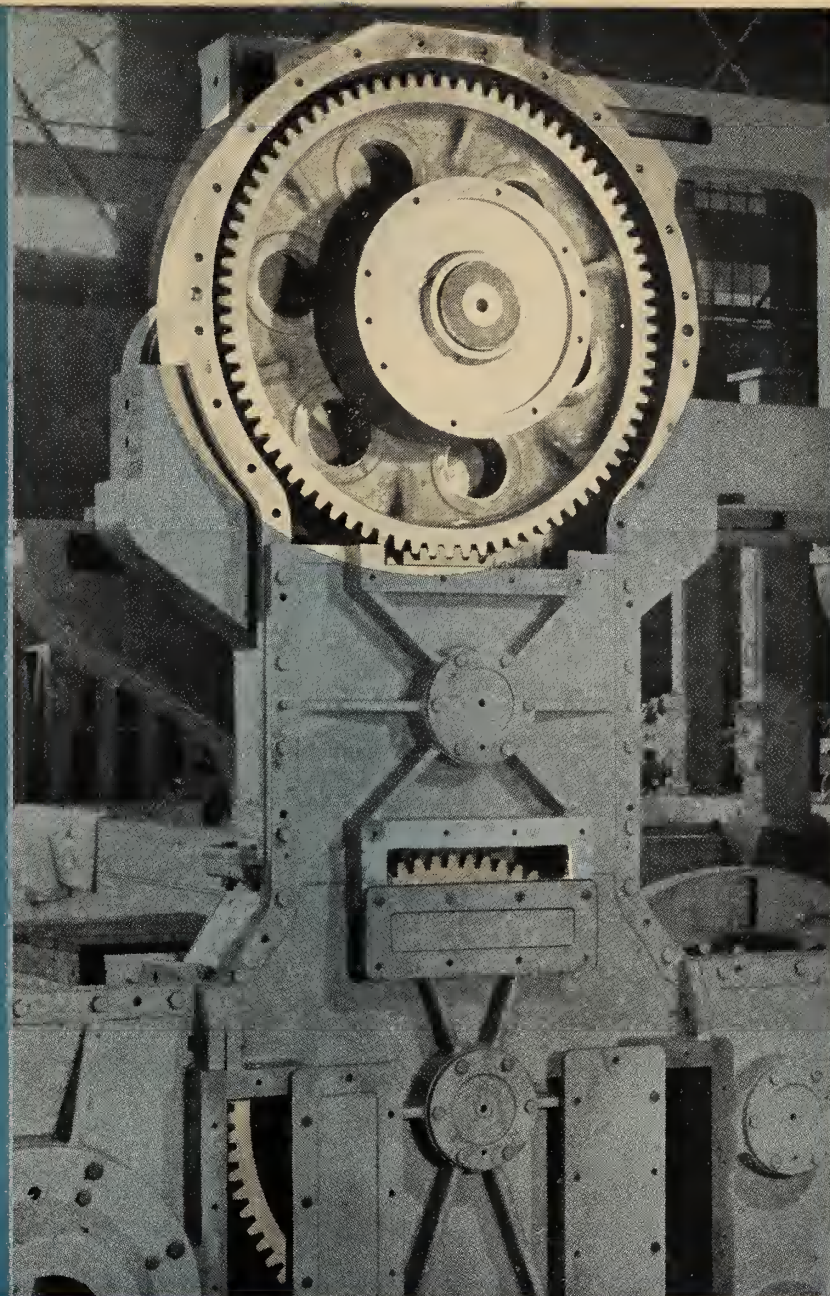
G. W. Spratt
M.E.I.C.

G. W. Spratt, M.E.I.C. (McGill '53), formerly of Macdonald & Macdonald Ltd., has been appointed Chief Engineer of Coast Testing Laboratories Ltd., Vancouver.

D. L. Mackinnon, M.E.I.C. (U.N.B. '39) is the new Assistant to the Vice-President, Administration, The Foundation Company of Canada Ltd., with headquarters in Toronto.

Karl E. Gustafson, M.E.I.C. (McGill '40), chief mining engineer for Pierce Management Corporation, Scranton, Penn., has recently completed inspection and report on two under sea coal mines in Chile, for the World Bank.

GEARS OF DUCTILE (NODULAR) IRON FOR THE WORLD'S WIDEST PAPER MACHINE



Built for Black-Clawson (Canada), Limited, these huge gears, for high speed paper production, were cast to give completely dependable, trouble-free operation. Once again, Canada Iron's technological facilities and large casting equipment were equal to the job.

Rely on Canada Iron's casting experts to help you find the exact casting grade for your needs. Let them show you the advantages of the right metal for the job . . . whether it be Ni-Hard, Ni-Resist, DOMITE* or Ductile (Nodular) cast iron. Consult your nearest Canada Iron office today.

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MEMBER

54Q

Obituaries

C. Ben Bate, M.E.I.C., died on May 26, 1960.

A graduate in civil engineering from Queen's University, 1915, Mr. Bate went to work on the engineering staff for the construction of additions to the Hawkesbury mill of the Riordon Company Ltd. He later joined Kerry and Chase Ltd. in Pushthrough, Newfoundland, where he worked on power investigation.

In 1958 Mr. Bate retired from Public Service and opened a private practice as a civil engineer at Sillery, Quebec. Just prior to retirement he had been a plant engineer with the Defence Research Board of the Department of National Defence, Quebec.

Mr. Bate was awarded the Order of the British Empire in 1945. He became a Life Member of the Institute in January, 1957.

Richard John **Herbertson**, S.E.I.C., a graduate of the University of Manitoba in mechanical engineering, 1959, was accidently killed on February 5, 1960.

Herbert Christopher Karn, M.E.I.C., former Chairman of the Standards Committee and Assistant to the Chief Engineer of Du Pont Company of Canada Ltd., died April 14, 1960, in his 70th year.

A native of Woodstock, Ontario, Mr. Karn received his degree in electrical engineering from the University of Toronto in 1916. Upon graduation he worked for Canadian Explosives Ltd. for a year in Beloeil, Quebec, then joined the British Munitions Company Ltd., Verdun, Quebec, and subsequently the Hydro Electric Power Commission of Ontario. In 1920 Mr. Karn rejoined Canadian Explosives Ltd. in Montreal and was appointed Supervising Engineer, Power Services, of Du Pont of Canada Ltd. in 1924. He held this position until 1953, when he was made Chairman of the Standards Committee.

Mr. Karn was involved in the construction and rehabilitation of plants in the many different works of Canadian Du Pont between these years. From 1939 to 1945 he worked on numerous projects in Quebec and Ontario for the storage of explosives. In 1946-47 he built the new plant and village at Chalk River. During the last years of his work with Du Pont, in 1953-54, Mr. Karn supervised the writing of engineering standards and segregated engineering records.

H. C. Karn, M.E.I.C.

A resident of Montreal until 1955, Mr. Karn retired to Windsor, Ontario, his birthplace. He was a member of the Corporation of Professional Engineers of Quebec, the Electrical Club of Montreal, and the Corporation of Master Electricians of Quebec; and a Life Member of the Institute.

James Mackintosh, M.E.I.C., for many years a member of the staff of the Hydro-Electric Power Commission of Ontario, has died in Toronto.

Mr. Mackintosh was born at Macduff, Scotland, and attended Gordon's College in Aberdeen and the Royal Technical College in Glasgow. He came to Canada in 1910, working first for the Ottawa Electric Company and then the Department of Railways and Canals as resident engineer on the Trent Canal. From 1917 to 1950 Mr. Mackintosh worked for the Hydro-Electric Power Commission of Ontario, after which he joined H. G. Acres, Consulting Engineers, for two years, working first at Pine Falls, Manitoba and later at Fanshawe Dam, London, Ontario.

A Life Member of the Institute and a member of the Institution of Civil Engineers, London, England, Mr. Mackintosh also belonged to the Scottish Rite of Masons; the Hunter and Anglers' Association; and the Royal Canadian Institute. He was an elder of the United Church for many years.

Arthur Hartley Milne, M.E.I.C., died on May 8, 1960.

A graduate in civil engineering from McGill University, 1917, Mr. Milne was appointed superintendent of buildings with the Protestant Board of School Commissioners of Montreal in 1926. Mr. Milne later worked for the firm deBelle & White, Architects, in Montreal.

Having joined the Institute as a Student Member in 1914, Mr. Milne was given Life Membership in January, 1956.

Vivian Andrew **Newhall**, M.E.I.C., retired city commissioner of Calgary, died recently. He was 71.

Born in Omaha, Nebraska, Mr. Newhall graduated from the University of Toronto, with a degree in civil engineering, in 1911. In that year he was also naturalized and moved to Calgary, where he began work with the federal government irrigation department and hydrometric surveys.

In 1913 he was architect's inspector on the Hudson Bay Company store, and the following year was appointed manager of Western Woodworkers, the construction department of Hudson Bay. He later became design engineer and manager of the Truscon Steel Company's agency in Calgary, and sales manager and a partner in Bell and Morris Ltd. when the agency was transferred to that concern.

B. A. Newhall, M.E.I.C

During World War II Mr. Newhall was chairman of the construction industry group in the payroll section of the National War Finance Committee. From 1944 to 1952 he served as city commissioner of Calgary.

An associate director of the Calgary Exhibition and Stampede Board, Mr. Newhall was also a Life Member of the Institute.

Other Societies

The Institution of Mining and Metallurgy, U.K.

The Annual General Meeting of the Institution of Mining and Metallurgy was held on May 19, 1960, at the Geological Society of London, Burlington House, Picadilly, London. Gold Medals of the Institution for 1959 were presented to Mr. Edward Duffield McDermott and Mr. Julius Kruttschnitt, and honorary memberships in the Institution were bestowed upon Sir Reginald Patrick Linstead, The Rt. Hon. Lord Robins, and George Augustus Whitworth.

Société Royale Belge des Ingénieurs et des Industriels

The 75th Anniversary of the S.R.B.I.I. was celebrated in Brussels from June 21 to 24, 1960. His Majesty the King and the Members of Government were present for the opening at the Palais des Académies. On June 22 a conference on the role of the engineer and the industrialist in the expansion of civilization was held, and on June 23 technical visits were made to Liège, Charleroi and Ghent. The object of the conference was to recall the activity of the Association since its founding in 1885 and to set out its prospects with emphasis on the development of applied sciences, scientific research, the equipment of the Belgian Congo, and the representation of the country abroad in the scientific, technical and industrial fields.

American Society for Testing Materials

The ASTM Division of Materials Sciences, as a part of the ASTM 63rd Annual General Meeting, held a special program from June 26 to July 1, 1960, on Recent Progress in Materials Sciences and the Nature and Origin of Strength of Materials.

The Associations and Corporation

The eighth annual convention of the Municipal Engineers' Division of the Association of Professional Engineers of B.C. will be held in Trail, September 15-17. New features of this year's convention will be a workshop for registered professional engineers employed by municipalities and a panel session by consulting engineers for works superintendents and suppliers.

Included in the convention program are tours of the Consolidated Mining and Smelting Company's Trail and Warfield operations. Over two hundred engineers, suppliers and wives are expected to attend. Sessions will be in the Cominco Centre. J. F. Millican, of Trail, will be the convention chairman.

Maritime Professional Engineers' Convention

One of the major engineering events of the Eastern Seaboard, the semi-annual Maritime Professional Engineers' Convention is being held this year at the Algonquin Hotel, St. Andrew's, New Brunswick, September 8-10. The four Maritime Professional Engineers' Associations and the Engineering Institute of Canada cooperate in its sponsorship.

The technical program will include: I. R. Cameron, Canadian Armament Research and Development Establishment, Quebec, Que., "Manufacture and Testing of Solid Propellent Rocket Engines"; J. E. Hayes, Canadian Broadcasting Corporation, Ottawa; R. J. Law, International Nickel of Canada, "Corrosion in Action"; and G. B. Williams, Assistant Deputy Minister of Public Works, Ottawa.

Institute of the Aeronautical Sciences

The annual national summer meeting of the IAS was held in Los Angeles from June 28 to July 1. General Curtis E. LeMay, vice-chief of staff, USAF, was the guest of honour and principal speaker at the banquet, June 30. Other speakers included: William H. Pickering, Dr. Theodore Von Karman, and Rear Admiral W. F. Raborn, USN.

Conference on Civil Engineering Education

The University of Michigan was host from July 6 to 8 to engineering educators from across the continent gathering for a conference on civil engineering education. Heads of departments of engineering from 138 colleges and universities with accredited curricula in civil engineering gathered to discuss the problem of decreasing enrollments and the need to attract better qualified students into the field.

Canadian Radio Technical Planning Board

The CRTPB was formed in September, 1944, at a meeting convened by the Department of Transport as an organization of users of radio communications and certain allied equipment, manufacturers, engineering and educational societies, and other interested organizations. Its object was and is to formulate sound engineering principles to assist in the development in accordance with the public interest, of the Canadian radio industry. Application for membership, or further information about the board, can be obtained from: The Secretary, Canadian Radio Technical Planning Board, 200 St. Clair Avenue West, Toronto 7.

The Institute of Physics and The Physical Society, U.K.

A new body was incorporated on May 17, 1960, under the name "The Institute of Physics and The Physical Society". The first president of the amalgamated body is Sir John Cockcroft.

(Continued on page 100)

News of the Branches

Border Cities

A TOUR was made of the recently completed Union Water System, by courtesy of the Ontario Water Resources Commission, on May 11. The plant featured the following automatic operations: chemical feed, compensation for plant and distribution demand variations, backwashing of filter beds, and switching of essential pumps to standby diesel power. The automated control at this plant is believed to be the most advanced on the continent.

V. Corin, JR.E.I.C.

Corner Brook

Robert G. Scott, JR.E.I.C.
Correspondent

THE HARBOUR development at St. John's is the largest single development ever undertaken by the Rivers and Harbours Branch of the Canadian Department of Public Works, according to Mr. Ed Manchul, of the Federal Department of Public Works, speaker at the May 11 meeting. The cost of the project, which is to be completed in 1963, is estimated at $13 million. A large finger wharf will be capable of handling ships of up to 10,000 tons and modern handling facilities and storage sheds will be available. The harbour is to be dredged, and an access road is being built along the North side of the harbour to enable traffic-handling cargo to bypass the downtown shopping areas. At the close of the meeting, Mr. Lowe, of Foundation Engineering Company, consultants for the project, discussed some interesting engineering aspects.

The main social event of the year in the Corner Brook Branch calendar was held on May 6 at the Glynmill Inn. Following cocktails and a lobster dinner, officers for the coming year were elected. They include: Robert Herdman, chairman; Max Promish, vice-chairman; Harold Hinton, secretary; and W. Cunen, treasurer. The outgoing chairman, Kevin George, paid tribute to one of the charter members of the branch, G. P. Hobbs, formerly Mill Manager of Bowater's Newfoundland Pulp and Paper Mills, who will leave Corner Brook shortly to take up the presidency of Bowater's Engineering and Development Incorporated, Calhoun, Tennessee. The evening ended with a dance in the cocktail lounge of the hotel.

CHALK RIVER ENCOUNTER: (left to right) Mr. A. H. Wilson; Mr. Hanna; and Mr. C. E. L. Hunt, past chairman of the Chalk River Branch.

Hamilton

C. A. McCurdy, JR.E.I.C.
Correspondent

THE CIVILS Group of the Hamilton Branch concluded their Spring activities with a tour of the Hunting Associates Ltd. plant in Toronto on May 18. Members had an opportunity to see equipment used in interpreting aerial photographs and plotting maps. Numerous illustrations were given of the uses of aerial photography in locating mineral outcroppings and making timber surveys. Aerial photography is also being used to show annual changes in cities. Toronto is completely photographed annually. The same technique is used in making plot plans of industrial installations.

Kitchener

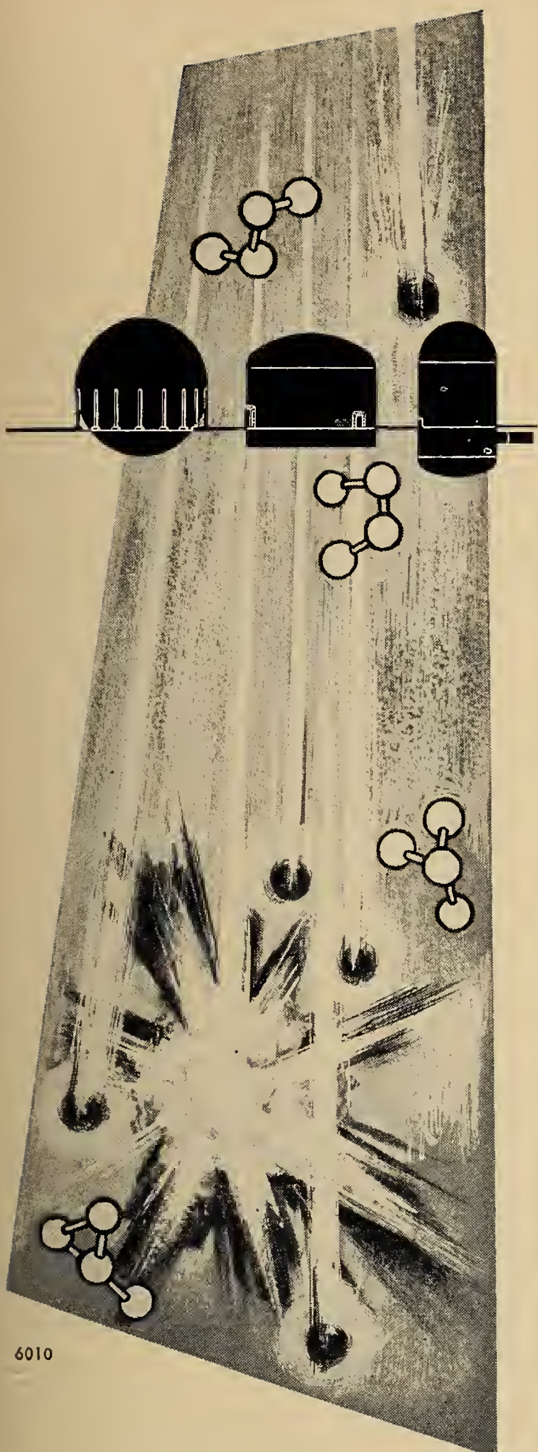
A. R. LeFeuvre, M.E.I.C.
Correspondent

A FIELD TRIP to the General Motors Diesel plant in London, Ontario, was held on May 27, and twenty-eight members of the Kitchener Branch took part. After an introduction by the Chief Engineer, the group toured the plant and enjoyed coffee and doughnuts in the plant cafeteria.

Kootenay

Ian Waterlow, M.E.I.C.
Correspondent

THE ROLE of the University of Industrial Development was discussed by Dr. F. Noakes, Dean of Electrical Engineering at U.B.C., at the May 9 meeting. Dr. Noakes traced the history of research in Canadian universities and most particularly at U.B.C., comparing it with that carried out in American universities. He noted the link between increased industrial activity around large research centres such as Stamford and MIT. Dr. Noakes enumerated the sources of research grants in Canada — NRC, the universities, industry and private funds. He stressed the good that can come from non-specific research on a large scale in a university, and made a plea to industry to take more interest in and supply more funds for university research.



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Lakehead

P. W. Pinn, M.E.I.C.
Correspondent

THE MAY 18 meeting of the Lakehead Branch was addressed by Mr. John T. Hunter of the Ontario Department of Highways. Mr. Hunter spoke of the immense amount of study which preceded the building of highways in the Province. He dealt with the subject of traffic surveys and explained traffic density's priority in highway construction allocations. At the present time the speaker showed that allocations are based on a program extending 20 years into the future.

University of Manitoba

THIRTY engineering students, from Nova Scotia to British Columbia, attended the E.I.C. Winnipeg Annual Meeting, May 24-28. The student delegates welcomed the opportunity to meet students from other school in other parts of the country.

The Winnipeg members are happy to have had the chance to be host to such a large and successful convention and hope that such an opportunity will be forthcoming again in the not-too-distant future.

Brian Grover, S.E.I.C.

Niagara Peninsula

Edward C. Little, M.E.I.C.
Correspondent

THE ANNUAL dinner and meeting at the Refectory, Niagara Falls, Ontario, was held on May 19.

Dr. M. Risley, Assistant Director of Education in New York, has made a hobby of humour in all its phases and his talk "He who laughs, lasts" was received with bursts of laughter. An introduction by F. R. Denham and vote of thanks by C. MacDonald were a splendid proof of what is being accomplished by the Professional Development Group.

The executive for 1960-61 includes: F. Ronald Denham, chairman; W. J. O'Reilly, vice-chairman; D. O. D. Ramsdale, past chairman; A. Alexander, treasurer; Harold Jones, Homer S. Lundy, R. McKimmie, W. D. Tanner, J. H. Travers, C. McDonald, W. J. Smith, members of the executive.

Peterborough

D. B. A. Chase, JR.E.I.C.
Correspondent

THE ANNUAL E.I.C. Field Trip was taken to the General Motors plant at Oshawa, on May 16. Approximately 45 members attended and were joined by three members of the Belleville Branch. The trip included a chicken dinner at the Flying Dutchman in Bowmanville. The tour, which was made in a small train, was followed by a lunch and very informative question period.

Following the popular custom of previous years, the winter's activities ended with the Annual EIC Stagg on June 3. This year the "Black Magic" Stag featured an hour-long presentation by Bradshaw the Magician.

The Peterborough Public Library has indicated a willingness to work with a newly formed Library Committee of the Peterborough Branch. The committee will help the library to choose new technical books; will prepare and distribute to members periodically a list of technical books available; and will encourage donations by members both directly and through the branch. Copies of the two biographies recently published by the E.I.C. have been presented to the library as initial contributions.

Vancouver Island

W. Tivy, M.E.I.C.
Correspondent

A CONDUCTED TOUR of the B.C. Forest Products Pulp and Paper Mill at Croften was taken by 28 members and wives on May 14. The tour was very complete, showing the transformation of raw logs into 500 lb. bales of kraft pulp. The capacity of the mill is approximately 600 tons per day.

On May 17 members heard Mr. Abraham Hurlich, head of the Materials Research Group of Convair Astronautics, San Diego, California, discuss materials and fabrication of the Atlas missile.

University of Waterloo

AN ORGANIZATIONAL meeting was held in April and the following officers were elected: John Shaw, president; Per Voldner, vice-president; William Wright, secretary-treasurer.

The film "Blasting A New Niagara", courtesy of Canadian Industries Ltd., was shown to a good attendance of faculty and students on May 13. The film portrayed blasting techniques used in construction of the underground tunnel and surface channel feeding the Sir Adam Beck No. 2 Hydro-Electric Generating Station at Niagara Falls.

A contest for the best technical paper from under-graduate engineering students is being sponsored by the student section. The papers are to be presented next Fall.

Carl Hamacher

Winnipeg, Electrical Section

A. C. Warrender, M.E.I.C.
Correspondent

THE WINTER activities for 1959-60 closed on April 8 with a smorgasbord and dance at Vasalund. Approximately 180 members, wives and friends enjoyed the fine food and pleasant evening of dancing.

The new executive for 1960-61 includes: A. S. Williams, chairman; D. C. Bryden, vice-chairman; R. M. Fraser, secretary; R. Akister, papers chairman; A. C. Warrender, recorder; G. Flavell, past chairman, D. E. Haig and C. E. Pontifex, members of the executive.

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*SYMPOSIUM ON MICROSCOPY.

The papers of this symposium on light and electron microscopy supplement the 1952 "Symposium on Light Microscopy" (ASTM-STP No. 143). Recent advances in microscopy are revised in a brief introduction, which also indicates that refinements and improvements are needed in sample handling and preparation techniques. Nine papers form the body of the symposium, discussing phase and interference microscopes, performance characteristics of objectives, eyepieces and illuminators; and microscopy in the optical, petroleum, ceramic, mineral and textile industries. (American Society for Testing Materials, Philadelphia, 1959. 165 p., $4.75. STP 257.)

TIMBER CONSTRUCTION MANUAL

Four years in preparation, this comprehensive manual covers all phases of timber construction and design, based on the latest CSA specifications. It includes data on both sawn timber and glued-laminated construction, and covers properties, stresses and loads; designs and design charts for beams, joists, columns, connectors, trusses and arches, decking and highway bridges, and information on shop detailing. There is a section on timber technology covering lumber grading and selection, load duration, thermal conductivity, preservative treatments, fire safety, etc. Also included is the complete CSA Specification 086, and C.I.T.C. appearance grade specifications. (Ottawa, Canadian Institute of Timber Construction, 1959. 368p., $6.50.)

> **THE ENGINEERING INSTITUTE LIBRARY**
>
> *The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.*
> *Library hours for June, July and August are: Monday to Friday: 2 p.m. to 5 p.m.; All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.*

*THE INDUSTRIAL COOLING TOWER

A great deal of wide-spread data has been collected and digested by the authors, who have combined it with their own experience to provide a co-ordinated survey of the whole field of cooling tower technology. Among those aspects treated are heat transfer in cooling towers; the natural draft cooling tower; cooling tower packing arrangements; drizzle precipitation, carryover, and wind effects; cooling water treatment; the structural design of cooling towers; auxiliary equipment, such as pumps and fans; and the construction of cooling towers. Both a theoretical and practical approach are provided. (K. K. McKelvey and M. Brooke. Toronto, Van Nostrand, 1959. 429p., $15.75.)

*FLUIDIZATION AND FLUID-PARTICLE SYSTEMS.

Modern developments in fluid-solids processing such as the moving bed techniques, fluidization, and transport reactors are discussed in this book. Includes material on angle of repose, internal and wall friction, rupture, slide, the application of particle shape factors in calculating fluid pressure drop, and bubble velocity and size of fluidized beds. (F. A. Zenz, and D. F. Othmer. New York, Reinhold, 1960. 513 p., $15.00.)

*ELECTRON TUBE LIFE FACTORS

This book deals with the changes in the properties of electron tubes for periods of time up to 5,000 hours of life under various environmental conditions. The properties measured include transconductance, power output, operation, heater and grid currents, heater cathode leakage, grid emission, interface resistance, and interelectrode insulation. Results of measurements, including percentage of failure, under both test conditions and MIL standard conditions are given, as well as general material on the characteristics, properties, and ratings of tubes, the design and control of the tests, and the analysis, presentation, interpretation and application of the data collected. (Ed. by Craig Walsh and others. Elizabeth, N. J., Engineering Publishers, 1959. 173 p., $9.50.)

*AVAILABLE ENERGY AND THE SECOND LAW ANALYSIS.

Introductory chapters are on the first and second laws of thermo-dynamics and are preparatory for the rest of the book, since both laws are considered in the following analysis of available energy in the mixing of gases, vapours, and liquids; heat-exchangers; turbo-blowers; air compressors; gas dynamics; refrigeration and power plants. The final chapters concern chemical changes, both theory and problems. (E. A. Bruges. Toronto, Butterworth, 1959. 124 p., $5.50.)

*GENIE CHIMIQUE, Volume 1; MECANIQUE DES FLUIDES.

This first volume of a series on the basic aspects of chemical engineering deals with fluid mechanics, and is meant to provide the engineer with tools and methods for solving both routine and more complex industrial problems. The volume is divided into 2 parts: the first, dealing with perfect fluids; and the second, with real (viscous) fluids. The final chapter is a study of the movement of a particle in a fluid, which provides the basis for several process applications: sedimentation, decantation, centrifuging, electrostatic precipitation, etc. (Rene Gilbert. Paris, Eyrolles, 1960. 216 p., 26.25 francs.)

*SECOND PROTECTIVE CONSTRUCTION SYMPOSIUM. PROCEEDINGS: DEEP UNDERGROUND CONSTRUCTION.

This large, two-volume loose-leaf collection of papers stresses primarily the design and construction of deep underground industrial facilities to resist the effects of nuclear weapons. Topics discussed include the need for shelters, weapons effects to be provided against, the interaction of utilities and structural solutions, tunnel design and failure mechanism, and experiences from such fields as submarine design, oil-well drilling, and underground powerhouse design. (Compiled by J. J. O'Sullivan. Santa Monica, Rand Corp., 1959. No price given.)

*MAGNESIUM AND ITS ALLOYS.

The extraction and refining of mag-

PEAK EFFICIENCY FOR HIRAM WALKER

Hiram Walker's new $4 million bottling plant at Walkerville, Ontario, contains the most modern and efficient materials-handling equipment ever developed for a beverage packaging operation. Speed and efficiency prevail — from the seven high-speed lines in the bottling room to the storage conveyors, controlled by an electric-eye system to avoid bottlenecking. As an essential part of this modern equipment, valves bearing the famous "Diamond" trade mark were chosen to service various units within the plant, including steam-heating and sprinkler systems, and sump installations. Whenever and wherever a Jenkins Valve is installed, you can be sure of the utmost in quality, reliability and economical performance. Jenkins Bros., Limited, Lachine, Que.

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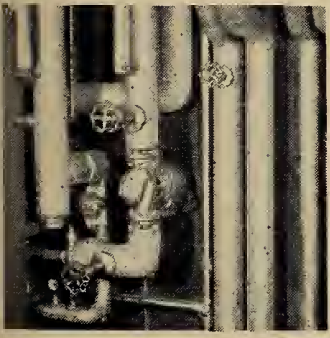

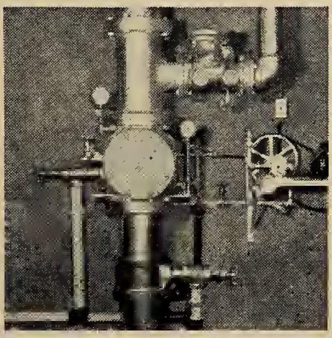

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nesium, alloy theory and phenomena, and the physical and chemical properties of the metal and its alloy systems are covered in detail. The technology of both casting and wrought alloys is included. (C. S. Roberts. New York, Wiley, 1960. 230 p., $9.00.)

*MECHANICAL PROPERTIES OF INTERMETALLIC COMPOUNDS.

The proceedings of the Electrochemical Society's 1959 Symposium, this book includes papers on the phenomenology of the mechanical behaviour of intermetallics, theoretical and experimental investigations of particular properties, experimental techniques for the preparation and study of intermetallics, and an extensive review of the literature in the field, from about 1908 to date. Included is an index to the compounds discussed. (Ed. by J. H. Westbrook. New York, Wiley, 1960. 435 p., $9.50.)

*MANUAL ON INDUSTRIAL WATER AND INDUSTRIAL WASTE WATER, 2nd ed.

Revision of the introductory section presents a general discussion of the characteristics and potential effects of waste water discharged from the plant, as well as of the characteristics of fresh water for industrial use. The remainder of this volume includes all current ASTM methods for the examination of water. (Philadelphia, American Society for Testing Material, 1960. 653 p., $11.00. s.t.p. 148-D.)

*BITUMINOUS PAVING MATERIALS.

This volume combines the papers presented at two symposiums, one on the methods of test for design of bituminous paving mixtures, and the other on the practical and statistical significance of tests and properties of bituminous binders, and at the technical session on road and paving materials. (Philadelphia, American Society for Testing Materials, 1959. 232 p., $5.50. s.t.p. 252.)

*SYMPOSIUM ON IDENTIFICATION OF WATER-FORMED DEPOSITS.

These five papers present analytical techniques for the identification of deposits in water systems, with discussions of the advantages and disadvantages of each method. (Philadelphia, American Society for Testing Materials, 1960. 74 p., $2.75. s.t.p. 256.)

*SYMPOSIUM ON ELECTRON METALLOGRAPHY.

This volume includes papers on the electron metallography of cast nickel, tin alloys with special attention to their phase morphology, and steels including the structural effects of neutron irradiation. Other papers discuss electron diffraction techniques and electron microphone measurements. (Philadelphia, American Society for Testing Materials, 1960. 128 p., $4.25. s.t.p. 262.)

*SYMPOSIUM ON EDUCATION IN MATERIALS.

Seven prominent engineers and educators present from their varying points of view the impact of engineering materials requirements as related to engineering educators. (Philadelphia, American Society for Testing Materials, 1960. 51 p., $2.00. s.t.p. 263.)

*SYMPOSIUM ON ELECTROLESS NICKEL PLATING.

Six American papers on practical and theoretical aspects of the catalytic deposition of nickel-phosphorous alloys by chemical reduction in aqueous solution. Topics covered include the history of the electroless plating process, the chemical reactions involved and the characteristics of the resulting deposits, process procedures, the advantages and limitations and applications of the process, and methods of testing the solutions used. Included also are an examination of patents in the field, and a bibliography of 136 references. (Philadelphia, American Society for Testing Materials, 1959. 67 p., $2.50. s.t.p. 265.)

NOTE: During the months of **June, July** and **August** Library hours are Monday to Friday, 2 p.m. to 5 p.m. only.

*TEXTILE ENGINEERING PROCESSES

Separate papers by experts in each particular topic provide a systematic examination of British textile engineering from the properties of natural and synthetic fibres, yarns and fabrics, to air properties, humidity and control. Examination of preparatory processes such as opening, drawing, spinning, winding, beaming and sizing follows the raw materials section and precedes discussion of manufacturing techniques such as wearing, knitting, water extraction, drying and conditioning, dyeing and printing. The final chapter describes and explains automatic control of textile plant machinery. (Ed. by A. H. Nissen. Toronto, Butterworth, 1959. 366 p., $9.25.)

*FLUORESCENT LAMPS AND LIGHTING.

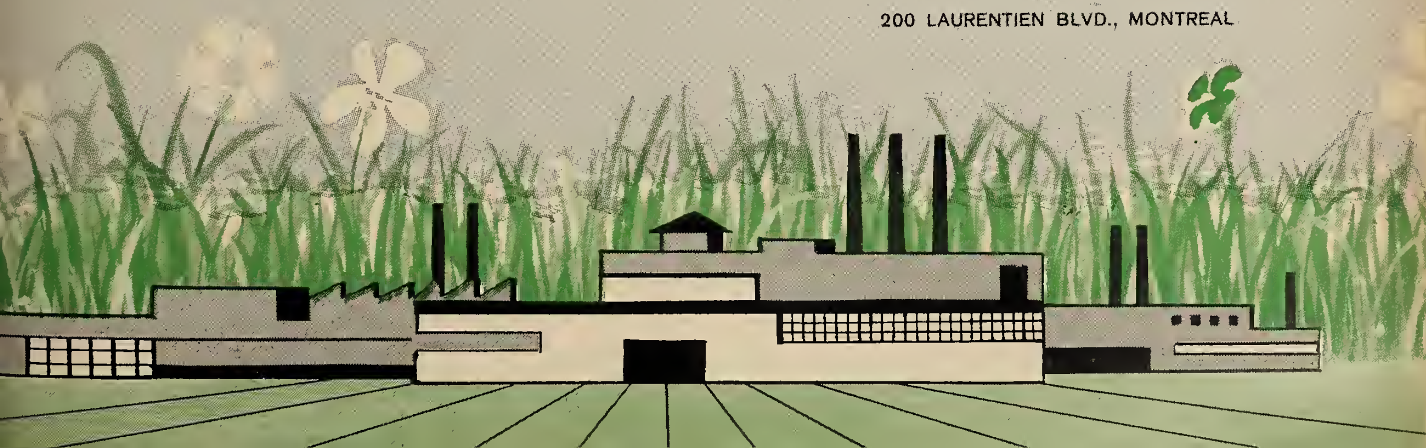
This second edition of C. Zwikker's *Fluorescent Lighting* contains the recent advances in fluorescent lighting techniques and lamp construction. Stabilization of the discharge and ballasts for AC operation are described and developments widening the use of tubular fluorescent lamps, including transistors, new circuits, ballasts, and reflector lamps are discussed. The subject matter of the book ranges from the physics of luminescence to public and private utilization of fluorescent lamps. The appendices discuss lamps with high loading per unit length and the application of transistors in lamp circuits. (Ed. by W. Elenbaas. Galt, Brett-Macmillan, 1959. 346 p., $11.00.)

*CEMENTED CARBIDES.

The historical development of cemented carbides traced in the first chapter is followed by chapters on production and testing methods for carbides and other metallic refractories, with emphasis on sintering. The mechanical and chemical properties of commercially produced carbides and those produced only in experimental quantities, such as oxide and boride materials form the next chapters, and the final chapters deal with applications of cemented carbides in the machine tool, mining, defence and other industries. (Paul Schwarskopf and others. Galt, Brett-Macmillan, 1960. 349 p., $15.00.)

*ENGINEERING ECONOMY, 3RD. ED.

All commonly used economy study methods here are analysed in terms of their background, principles and procedures, together with discussion of the frequent importance of non-monetary factors in economic decisions. This edition is almost completely rewritten. (E. P. de Garmo. Galt, Brett-Macmillan, 1960. 580 p., $8.75.)



*MATRICES.

An introductory college-level development of the theory of matrices. After a review of elementary mathematical concepts, the theory is introduced through linear forms and systems of equations with a complete matrix treatment. The theory of determinents is made to depend on the theory of matrices. Also included are discussions of row and column transformations, equivalence and rank, elementwise and blockwise operations, partitioning, and the MURT technique. (W. Vann Parker and J. C. Eaves. New York, Ronald, 1960. 195 p., $7.50.)

*CHEMICAL ENGINEERING PRACTICE, VOLUME 11: WORKS DESIGN, ETC.

This volume of the series contains papers on the planning and administration of chemical works and factories. The planning stage includes layout and execution of the design, the choice of a site, the design and construction of the building, contracts, and the installation of the works. Administration of employees and materials, quality control, accounting, and cost control are covered in the next chapter. British legislation relevant to chemical factory management and regulation, the industrial hazards of the chemical plant, and British patent regulations are also dealt with. (Ed. by H. W. Cremer and S. B. Watkins. Toronto, Butterworth, 1959. 390 p., $19.50.)

*AIRCRAFT AND MISSILE DESIGN AND MAINTENANCE HANDBOOK.

This work is applicable for piston-driven and jet planes, helicopters and guided missiles. Technical data on electrical and plumbing systems, materials of construction, hardware, color codes, and on processes such as metal spraying, anodizing, plating, and welding are presented here, along with numerous tables and figures illustrating standard methods of equipment installation. The text explains the methods and gives guidance in the handling of materials and tools. (C. A. Overbey. Galt, Brett-Macmillan, 1960. 369 p., $9.75.)

*CATHODIC PROTECTION.

This practical book on the prevention of corrosion by electrolytic means, describes the making of the necessary field surveys and tests, the interpretation of test results, and the design and construction of the appropriate cathodic protection installations. Operational examples of the protection of such underground and submerged structures as pipelines, cables, aviation fuel tank and line systems, lock and dam gates, and ships in storage are given. Also included is an examination of the relationship of cathodic protection to static and power grounding systems. (L. M. Applegate, Toronto, McGraw-Hill, 1960. 229 p., $10.35.)

*ELEVATORS, 3RD. ED.

Comprehensive and practical information on the construction, operation and maintenance of vertical transportation equipment in public and private structures, for maintenance men, mechanics, engineers, and others concerned with elevators, escalators, moving sidewalks, and ramps. Topics covered include a/c, d/c, and electrohydraulic machinery, methods of roping, signals, and safety systems. New material includes conformity with 1955 A.S.A. standards, and electronic and automatic innovations. (F. A. Annett. Toronto, McGraw-Hill, 1960. 388 p., $13.25.)

*HIGHWAY ENGINEERING HANDBOOK.

Written by specialists in each field, the 28 sections in this comprehensive book cover almost every aspect of highway engineering with the primary exception of structures. The first part covers highway administration, finance, planning, economics, route selection, photogrammetry, computers and traffic engineering. Soil testing, exploration, drainage, earthwork, frost, foundations, slopes, etc. are treated in part 2. Part 3 deals with contracts, specifications, soil stabilization, Portland concrete and bituminous materials and mixes. Part 4 includes design and construction of rigid and flexible pavements, highway maintenance and landscaping. (Ed. by K. B. Woods and others. Toronto, McGraw-Hill, 1960. Various pagings, $28.75.)

*SCIENCE AND RESOURCES.

Some of the difficult and critical questions arising from recent advances in science and technology are explored in this collection of paper originally presented at the 1959 Washington "Resources for the Future" Forum. A lead essay in each of the six topical sections discusses advances and state of current knowledge in a specific field, and is followed by two essays discussing the economic, social and political impact of the advances. The six sections deal with human and animal genetics, weather control, geological exploration, chemical technology, nuclear energy and peaceful use of atomic energy, and space exploration. (Ed. by H. Jarrett. Baltimore, Johns Hopkins, 1959. 250 p., $5.00.)

*ADVANCES IN SPACE SCIENCE, VOLUME I.

Embracing nearly all phases of human scientific knowledge, space science has the principle objective of manned space travel and exploration. Bioastronautics—concerning human aspects of space travel—is treated here directly, in articles on manned space cabin systems, the effect of radiation on man in space, and the nutritional aspects of space flight, and indirectly in articles dealing with orbits and interplanetary trajectories, interplanetary communications, and the problems of power supply on board orbital and space vehicles. The latest revision of the Sänger system for the classification of astronautical literature is included as an appendix. The first volume of a projected annual publication. (Ed. by F. I. Ordway, III. New York, Academic, 1959. 412 p., $12.00.)

*SIMPLIFIED DESIGN OF REINFORCED CONCRETE, 2ND. ED.

Prepared in compliance with recommended unit stresses and design procedure and requirements as given in the ACI Building Code Requirements, a major portion of this book consists of illustrative examples of the design of structural reinforced concrete members. This second edition has several new features, including identification of bar sizes by numbers instead of dimensions, an explanation of the practice of using all straight reinforcing bars in the design of beams, current requirements of web reinforcement, and a chapter on the theory and economic advantages of prestressed concrete. New tables have been added, and all new figures are given. (H. Parker. New York, Wiley, 1960. 303 p., $6.50.)

***SCIENTIFIC PAPERS OF SIR GEOFFREY INGRAM TAYLOR, VOLUME II: METEOROLOGY, OCEANOGRAPHY AND TURBULENT FLOW.**

The phenomenon of turbulence and its effect provide the main theme of this, the first of three volumes in this series to be devoted mostly to Taylor's work on the mechanics of fluids, but it also contains a wide range of geophysical investigations. Included are papers on diffusion in the atmosphere, formation of fog, tidal friction, tidal oscillations in gulfs, oscillations of the atmosphere, stability of stratified fluids, and convection from sources. (Ed. by G. K. Batchelor. Toronto, MacMillan, 1960. 515 p., $12.75.)

***PROGRESS IN SEMICONDUCTORS, VOLUME 4.**

This fourth volume in the series contains papers from the Soviet Union, England, Germany, Holland, Japan, and the United States. The scope of the discussions is shown by the titles of the papers: negative effective masses in semiconductors; oxidation phenomena on germanium surfaces; theory of avalanche multiplication in non-polar semiconductors; internal field emission; noise in semiconductors; the electrical effects of dislocations in semiconductors; dielectric properties of solids in relation to imperfections; non-crystalline, amorphous, and liquid electronic semiconductors. (Ed. by A. F. Gibson and others. New York, Wiley, 1960. 291 p., $10.50.)

***MARINE LUBRICATION.**

This book describes the properties, refining, testing and filtration of lubricating oils, the fundamental principles of their use, and the prime movers in which they are used, dealing specifically with the marine power plant and its auxiliary machinery, which have similar lubricating requirements whether used on land or sea. Machinery described includes diesel engines, steam engines, turbines, pumps, compressors, refrigerating, steering and deck machinery, and their fuels. (G. H. Clark. New York, Simmons-Boardman, 1959. 635 p., $16.00.)

***THE INSTRUMENT MANUAL, 3RD. ED.**

Contains descriptions of the purpose, principles, design, and materials of individual instruments used in all areas of measurement and control. The main additions to this third edition are in the fields of nucleonics and viscosity, and in a new section on analogue computers; the earlier chapter on navigational instruments has been omitted. Among the areas of measurement and control by instrumentation discussed are weight, conductivity, hydrogen ion concentration, fluid flow, specific gravity or density of liquids, viscosity, pressure and vacuum, temperature, and moisture content of air and gases. Also described are electrical and electronic measuring instruments, aeronautical, surveying, analytical, meteorological, counting, and timing instruments, as well as microscopes, telemetering systems, and various highly specialized types. (London, United Trade Press, 1960. 742 p., £5.5.0.)

***ENGINEERING THERMODYNAMICS.**

This undergraduate text concentrates on fundamental concepts, the first and second laws, and physical property relationships. It does not attempt to cover all engineering applications of thermodynamics, but illustrates applications of the basic principles presented in the first fourteen chapters in six chapters on fluid flow, fluid machines, gas and vapour power cycles, refrigeration, and binary mixtures. The elements of heat transfer are briefly discussed in the final chapters. Dimensions and units, and a variety of thermodynamic charts and graphs are given in appendices. (J. B. Jones and G. A. Hawkins. New York, Wiley, 1960. 724 p., $8.50.)

● OTHER SOCIETIES

(*Continued from page 89*)

Courses Offered

Illinois Institute of Technology (Chicago) X-Ray Diffraction Analysis, September 12-16.

Ohio State University (Columbus), Process Industry Corrosion, September 12-16.

University of California (Berkeley), Corrosion Fundamentals; Solid State Theory; Nuclear Reactor; Process Industry, October 3-5.

Coming Events

Symposium on Reinforced Concrete Design, Queen's University, August 29-September 2.

Seventh Canadian Textile Seminar, Queen's University, September 7-8.

ASCE Conference on Electronic Computation, Pittsburgh, September 8-9.

Meetings with CCA Affiliates in Atlantic Provinces, Fredericton and Saint John, N.B., September 19; Halifax, N.S., September 20; St. John's, Nfld., September 22; Sydney, N.S., September 23.

Meeting on Non-Destructive Testing, Cheltenham, England, September 22-24.

National Material Handling Show (Canadian chapters of American Material Handling Society), Montreal, September 26-30.

Sixth Annual Convention of Prestressed Concrete Institute, New York City, September 27-30.

National Association of Corrosion Engineers, Southeast Regional Conference, Atlanta, Ga., October 6-8; Northeast Regional, Huntington, W. Va., October 11-14; South Central Regional, Tulsa, Okla., October 25-27.

Society of Automotive Engineers National Aeronautic Meeting, Los Angeles, October 10-14.

National Electronics Conference, Chicago, October 10-12.

First Effluent and Water Treatment Exhibition and Convention, London, October 18-21.

Society for Experimental Stress Analysis, Annual Meeting, Berkeley, Calif., October 19-21.

● ELECTIONS AND TRANSFERS

(*Continued from page 80*)

Royal Military College: P. R. Detracey, P. E. Corbeil.
University of Western Ontario: H. E. Doyle, N. D. McLennan.
Carleton University: R. G. Clark, W. J. Robertson.
Student of Corporation of Professional Engineers of Quebec: L. Ecker, J. P. Virus.
University of Ottawa: V. A. Hutchinson
Ontario Agricultural College: J. C. Fullerton
Dalhousie University: P. W. Jost
University of Alberta: L. E. Fisher
Pratt Institute: M. M. W. Shotwell (Miss)
Automatic Transfers—Student to Junior: J. A. P. A. Sauvageau, Donnacona, Que.; C. Lemyre, London, England.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective.

ALBERTA

Member: C. A. Fitch.
Junior to Member: J. Abugov, G. Adam, B. C. Bell, W. G. Brander, M. J. Dolinsky, D. J. Forest, J. H. Graham, G. V. Greenwood, R. J. Hollingshead, C. D. Howarth, W. Hrynchuk, E. M. Johnson, R. C. Legge, P. Leonidas, W. K. Miller, A. H. Nicolson, J. R. O'Brien, G. W. Oliver, E. M. Overn, W. J. Ozga, D. J. Parry, J. P. Patterson, L. A. Pearce, N. L. Reid, H. F. Rogers, D. R. Seaman, H. M. Simpson, R. Stollery, W. R. Tinkess, G. W. Walker, C. A. Walrath.
Student to Junior: E. G. A. Henderson.

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THE INDUSTRIAL DEVELOPMENT BANK, Montreal, requires a graduate, registered professional engineer having several years diversified employment in secondary industry in Canada. Duties will include studies and reporting on industries. Financial analysis experience valuable but not essential. Must be bilingual. Applicants should be between the ages of 25 and 35. This is a permanent position and provide pension and insurance benefits. Candidates should forward a comprehensive resume. File No. 6999-V.

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CHIEF ENGINEER. Age 35 to 45 for complete responsibility of design office. Structural, electrical and mechanical for work on process and chemical plant projects. Require consulting engineering background with client relationship experience. Excellent opportunity with large organization. File No. 7053-V.

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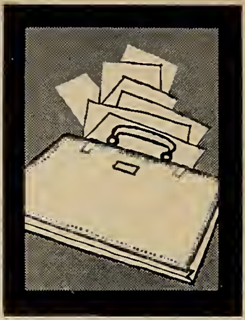
Business and Industrial Briefs



Appointments and Transfers

J. Warren Millard has been appointed Manager, Eastern District Sales, for Carbide Chemicals Company, a division of Union Carbide of Canada. Mr. Millard assumes responsibility for the Company's chemicals and plastics sales in the Province of Quebec, the Ottawa Valley and the four Atlantic provinces. He will continue to make his headquarters in Montreal.

Four appointments in the Industrial Products Department of Canadian General Electric have been announced. **Joseph K. McLinden** has been given responsibility for Manufacturing instrument and specialty transformers. **Robert D. Maguire** has been appointed Manager, Engineering. **Robert M. Love** becomes Manager, Sales, and **George I. Campbell** is now Manager, Product Planning.

Dominion Engineering announces the appointment of **A. T. Setter** as Sales Manager of the Gear Products Division. Since graduating in Engineering from McGill in 1950, Mr. Setter has worked in various sales capacities throughout Eastern Canada.

Frank N. Buckley has been appointed Vice-President, Sales, of Aero Survey Ltd. Mr. Buckley will direct the sales activities of this company which specializes in aerial photogrammetry, airborne profiles, and airborne geophysical surveys.

New Developments

A PILLOW BLOCK which permits quick replacement of bronze precision liners without removing the bottom half of the housing from its support has been introduced by United Steel Corporation of Toronto. Only the cap half is removed—the shaft is lifted enough for the lower half of the liner to slip out and allow insertion of a new liner. A brass retainer spool recessed between cap and base of housing prevents rotation of the liner with the shaft and eliminates the need for screws. These units are recommended where shock load, high temperature or corrosive conditions prevail.

DOOR-SIZE PANELS in transparent plastic are now offered by Du Pont for use in the construction of greenhouses, car-ports, temporary hangars for small planes, etc. "Mylar" polyester film has a tensile strength equal to one-third that of machined steel. The portable panels measure 6 feet by 3 feet and are rimmed with lightweight aluminum.

STAINLESS STEEL DESIGN will be illustrated in photographs at an International Exhibition arranged for this Fall by the National Industrial Design Council in Ottawa. Atlas Steels, International Nickel and Union Carbide are co-operating to give recognition in this way to the services offered by industrial designers, architects and artists.

A LARGER REACTOR than any at present known may begin to take shape next year. Southern California Edison Company has sent Westinghouse a letter of intent for the design and construction of a 360,000 kw. nuclear power plant. Westinghouse will build the reactor at an estimated cost of $70 million. This type of plant has a 300 ton reactor vessel in which uranium oxide fuel elements are suspended. Water under a pressure of 200 p.s.i. is circulated around these elements, through a heat exchanger, and transfers heat to a secondary system where water is converted to steam to turn the turbine-generator. Westinghouse will supply the steam and electrical equipment for this installation, which will supply enough electricity to meet the residential needs of more than 500,000 people.

SEA WATER distillation is to be employed in Canadian Pacific's new liner "Empress of Canada", built by Vickers-Armstrongs at Walker-on-Tyne. A Weir closed feed system and a Weir sea water evaporating and distilling plant are being installed.

AIRSHIPS may help solve a perplexing space-age problem — transportation of eight-storey-high rocket boosters from factory to launch pad. This is the opinion of Goodyear experts who recently completed a feasibility study. Their analysis indicated that modern non-rigid airships could land practically at the door of the rocket booster factory, pick up a 40 ton booster, and deliver it to the launch site in the United States or overseas. No heavy duty runways would be required — only a comparatively smooth area about 2,300 ft. long.

THE MAGAVERTER, a completely static, solid state, precision analog-to-voltage-to-frequency converter, has just been introduced by Pioneer Magnetics Incorporated of Santa Monica, California. The Magaverter uses only tough, solid state components to produce an output square wave of frequency directly proportional to the input voltage.

GOLD-PLATED frame-grids in the tube permit a very small grid-to-cathode clearance in the Philips 7308/E188CC Special Quality Double Triode, now available from Rogers Electronic Tubes and Components. This results in a mutual conductance of 12.5 mA/V at an anode current of only 15 mA. Both tube sections are separated by a screen, and their cathodes are connected to separate pins. Outstanding microphonic properties make this triode ideal as a cascode amplifier or cathode follower in H.F. and I.F. circuits. Vibrational noise output is 140 mV maximum at vibrations between 50 and 5000 c/s at 0.5 g, and 100 mV maximum at vibrations between 10 and 50 c/s at 2.5 g.

OVER 1000 TONS of aluminum in one all-welded structure is a very unusual feature of construction even on land. The 40,000 ton Oriana now being built for the Orient Line by Vickers-Armstrongs will have this much aluminum in her superstructure. Equipment for the automatic and semi-automatic welding includes self-propelled machines as well as a specially designed welding gantry with four automatic welding heads. Two of the heads are for the welding of aluminum, and the other two are for welding steel sections by the FUSARC/CO_2 process. Quasi-Arc, Ltd., a subsidiary of British Oxygen, supplied the equipment.

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• DISCUSSION

(Continued from page 69)

search (i.e. short-term research on the engineering principle involved) in a particular country are not always applicable to other regions, as stated by the author. Thus, in highway planning, design, construction, maintenance and operations there are some typical Canadian problems involved, which can only be studied in this country. This is due to the particular climatic conditions, certain types of construction materials and plant, the general rising economy and rapid rate of expansion in this country and the necessary training of more Canadian highway engineers. The co-ordinating activities of the Canadian Good Roads Association are, therefore, of great importance in ensuring that the special Canadian highway research problems are receiving attention and the results of such work are disseminated with the least possible delay.

Of special importance in the writer's opinion is the author's finding that the amount of research sponsored or carried out by provincial highway departments and the federal highway division in this country is exceptionally small when compared with the magnitude of highway construction undertaken. It appears that most of the Canadian highway research is at present being carried out by our universities or in cooperation with them. In this connection it may be noted that in civil engineering research in Canada generally, about three-quarters of all research is carried out by government departments and only one-quarter (in approximately equal proportions) by the universities and by industry. When it is realized that the planning and design of highways are almost entirely the responsibility of public highway departments, their small contribution to highway research in Canada is rather difficult to understand.

It would therefore seem reasonable to expect, as the author has indicated, that a much greater proportion of highway research should be carried out and financially supported by our public highway departments. The highway problems of general interest to Canada could probably best be solved by setting up under some federal authority, possibly the National Research Council, a National Highway Research Division with its own staff, laboratories and field equipment as has been done in other countries. The problems of special interest to the individual provinces, however, could best be solved by provincial joint highway research projects similar to those operating in Ontario and, to a smaller extent, in

Alberta in cooperation with the local universities in the particular province concerned. In this way, the local problems of highway engineering can be studied in the different areas and the solutions could then be directly applied in the province concerned.

For this cooperation between provincial highway departments and local universities, many more scholarships for graduate studies in highway engineering are urgently required in Canada, and some of these may well be set up by the local industry and the various highway departments for whose benefit the research is partly carried out. In addition, the highway departments should enable their own engineers to obtain special study leave of absence so that they can enrol in postgraduate courses in our universities, possibly under the suggested scholarship scheme. The writer believes that this approach would encourage highway research in Canadian universities considerably and at the same time it would give ample opportunity for such studies to be combined with field investigations without which the results of highway research are likely to be of limited value.

Author's reply:

Dr. Meyerhof has stated that "it appears that most of the Canadian highway research is at present being carried out by our universities or in cooperation with them". In so far as the numbers of individual projects are concerned this statement is very nearly true. However, in terms of the amount of money spent on research this is not the case. A check of our files reveals that approximately 40% of the highway research expenditure is made directly by the provincial highway departments, about 40% by the federal, municipal and other provincial government departments and agencies, slightly less than 20% by the universities and the remainder by industry. It is still apparent that the investment of the highway departments in research is too small but we are encouraged by their rapidly expanding activities in this field during the past few years.

The author heartily endorses Dr. Meyerhof's suggestion for greater cooperation between the highway departments and local universities and for an increase in the number of scholarships available for graduate studies in highway engineering. This, plus a further increase in university research work, cannot but help the highway departments and industry both through the development of solutions to current problems and through the increased supply of trained specialists from the graduate schools.

Somewhat contrary to Dr. Meyerhof's suggestion, the author feels that the best plan for carrying out the majority of both applied and basic research on highways is by having the necessary projects carried out by the universities and by highway departments working in close cooperation. This procedure would ensure the development of both the staffs and facilities of the universities and highway departments and would further ensure that the results of research are quickly recognized and incorporated into current design and construction practice.

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Index to Advertisers

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JULY, 1960

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THE ENGINEERING JOURNAL

PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA   VOLUME 43 NUMBER 8   AUGUST 1960

PUBLISHED BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-5078

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Meet the Authors

A note on **N. S. Bubbis**, M.E.I.C. (*Aqueduct and Pumping Station for Greater Winnipeg*) appeared in the June 1960 issue of The Engineering Journal.

R. Craig Sommerville, Jr. E.I.C., B.Sc. Civil (Manitoba '49), Design Engineer, Greater Winnipeg Water and Sanitary Districts, St. James, Manitoba. (*Aqueduct and Pumping Station for Greater Winnipeg*).

R. C. Sommerville, M.E.I.C.

Mr. Sommerville spent three years with Canadian National Railways at Hornepayne and Toronto before joining the Greater Winnipeg Water District in 1952. He is now responsible for their Design Department. He took his M.A.Sc. in Public Health Engineering at the University of Toronto in 1954.

Donald P. Wyness, B.Sc. Mechanical (U.B.C. '41) Project Engineer, Sandwell and Company Limited, Vancouver, B.C. (*The Khulna Newsprint Project*).

Mr. Wyness has had wide experience in the lumber and pulp and paper industries as a design engineer, working in various parts of British Columbia. He joined Sandwell and Company of Vancouver in 1951 and was their project engineer in charge of the Khulna newsprint project. He remained in East Pakistan a further year as Resident Engineer at Khulna. This year Mr. Wyness is Project Engineer on Rayonier Inc.'s fine paper mill expansion in Hoquiam, Washington.

David Panar, M.E.I.C., B.Sc. Mechanical (Michigan '41), M.Sc., Associate Professor of Mechanical Engineering, University of Alberta, Edmonton. (*The Economics of an Industrial Gas Turbine*).

D. Panar, M.E.I.C.

At the time Professor Panar took his M.Sc. at the University of Michigan in Industrial Engineering, he was also on their staff as a special instructor. He then entered private consulting practice in air conditioning. He has been on the staff of the University of Alberta since 1946 and continues his consulting work in power plants, heating and ventilating.

E. M. Rensaa, M.E.I.C., B.Sc.Civil (Manitoba '33), M.Sc., Partner, Rensaa and Minsos, Architects and Consulting Engineers, Edmonton, Alberta (*Joints in Precast Concrete Building Frames*).

After working with the C.N.R. and the Federal Department of Public Works in Winnipeg, Mr. Rensaa returned to Norway, his native country, for nine years and started his own designing and consulting practice. Since 1947 he has been a partner in a consulting firm in Edmonton which has pioneered in the development of precast reinforced concrete framework. Mr. Rensaa is a member of the advisory committee on structures and of the reinforced concrete committee of the National Building Code, and has written numerous articles on structural engineering and engineering education.

Walter J. Pearson, M.E.I.C., B.A. Geology (Saskatchewan '50), M.A., Ph.D., Industrial Minerals Geologist, Mines Branch, Provincial Department of Mineral Resources, Regina, Saskatchewan. (*Western Canada Potash and Its Future Prospects*).

Dr. Pearson did geological surveying in several parts of Canada during the field seasons of 1949-55. He joined the Department of Mineral Resources in 1956, and obtained his Ph.D. from Queen's University last year.

Charles D. Stewart, M.E.I.C., B.Sc.Agricultural Engineering (Saskatchewan '49), M.Sc., Ph.D., Professor and Head, Agricultural Engineering Department, University of Saskatchewan, Saskatoon. *(Irrigation Land Development Policies for Saskatchewan).*

C. D. Stewart, M.E.I.C.

Dr. Stewart spent five years in the R.C.A.F. prior to attending university, and was with the Prairie Farm Rehabilitation Administration for a year before doing post graduate studies at U.S.A.C., Logan, Utah. He then rejoined P.F.R.A. for four years as Drainage Engineer, Acting Head of Drainage Division. Dr. Stewart is the Chairman of the South Saskatchewan River Development Commission and of the Saskatchewan Farm Safety Committee. He is a member of numerous other professional societies.

COVER ILLUSTRATION

Aqueduct for Greater Winnipeg: primary wall lining and pipe bed in place prior to grouting. *(Photo by Portigal.)*

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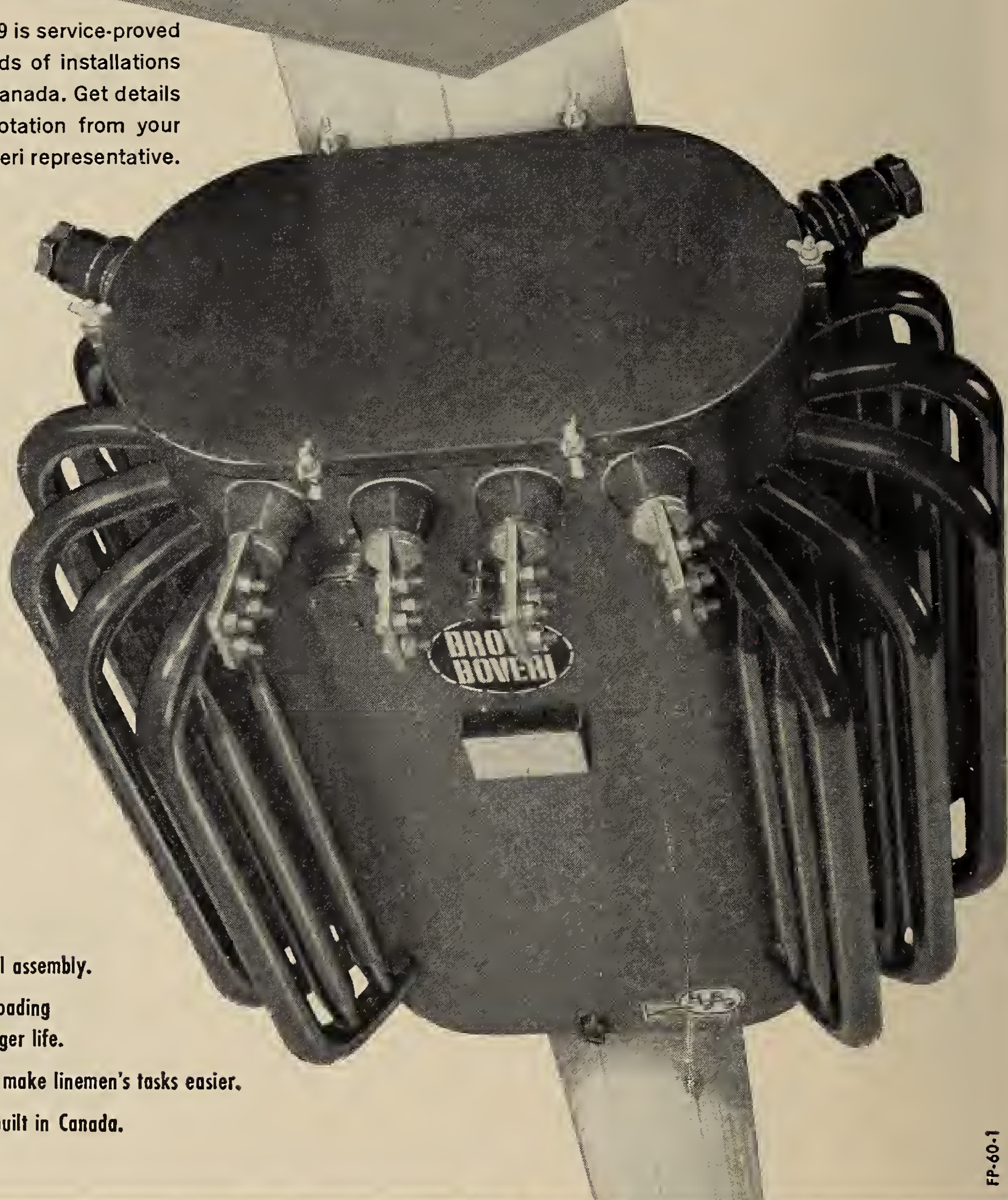

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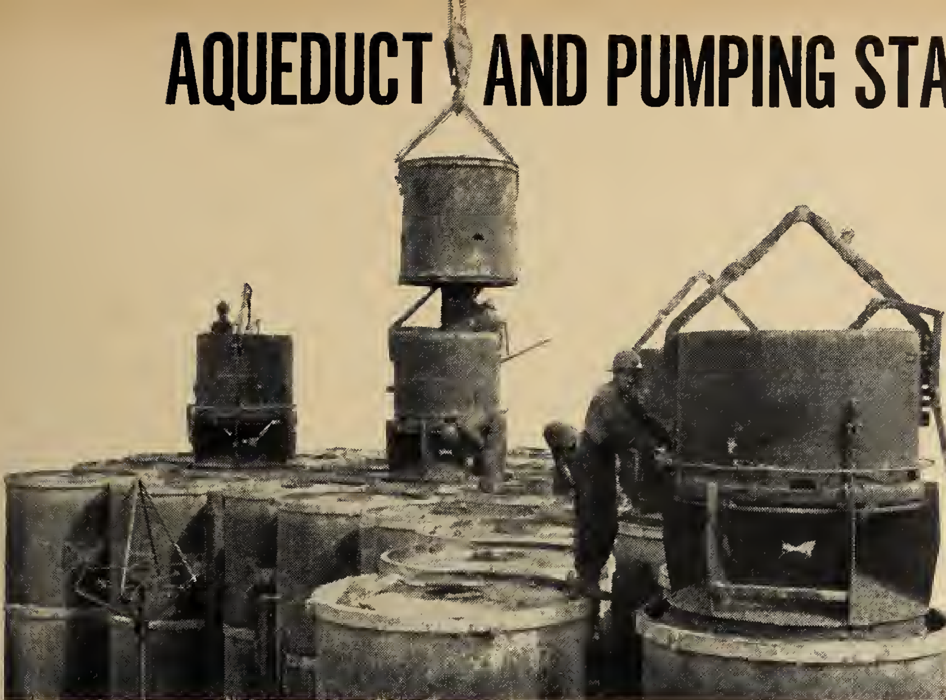


N. S. Bubbis,
M.E.I.C.,
General Manager-Chief Engineer, Greater Winnipeg Water and Sanitary Districts

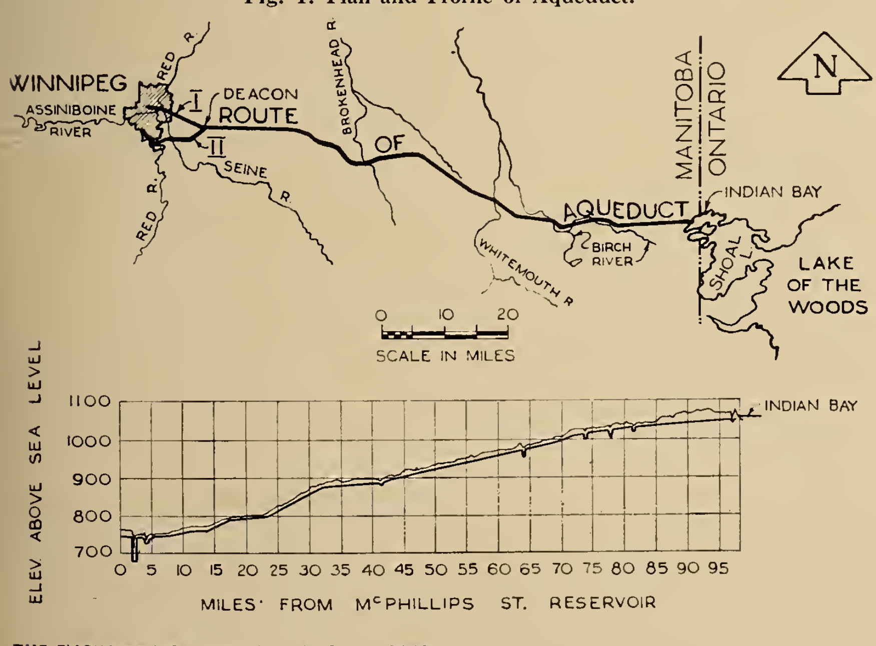
R. C. Sommerville,
JR.E.I.C.,
Design Engineer, Greater Winnipeg Water District

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

The Greater Winnipeg Water District was organized in 1913 to bring water from Lake of the Woods to Greater Winnipeg. Between 1915 and 1919 an aqueduct 97 miles in length was built from Indian Bay, on the Manitoba-Ontario boundary, to the City of Winnipeg reservoirs. The most easterly 84 miles, comprising a gravity section of 80 miles and a pressure section of 4 miles, has a capacity of 85 m.g.d. with the continuing pressure section having a capacity of 50 m.g.d. Provision was made for a future addition, which is now under construction, as is also a low lift pumping station at Indian Bay. This paper will describe the design and construction of these projects.

THE CITY of Winnipeg's first water supply system was established in 1888 with water being taken from the Assiniboine River. This source proved unsatisfactory, due to the uncertain quantity, the poor quality despite filtering, and also its doubtful purity. The water was very highly turbid during seasonal run-off and was very hard, requiring the construction of the first lime soda ash softening plant in North America. At the turn of the century this source was changed to wells. While the well water was of excellent quality, it was extremely hard (and not amenable to softening) and it very quickly became apparent that wells could not be relied upon to supply the quantity of water which would be required by the very rapidly growing city.

Fig. 1. Plan and Profile of Aqueduct.



A number of engineering studies were made between 1906 and 1912 with several different water sources being considered. A report made to the Public Utilities Commission in 1912 recommended Shoal Lake as the source and suggested that the adjacent municipalities might join in the project. The Greater Winnipeg Water District was then established with the responsibility of bringing Shoal Lake water into the Greater Winnipeg area. A Board of Consulting Engineers was appointed on April 7th, 1913 to prepare a report upon the best means of supplying the area with water from Shoal Lake, together with an estimate of cost, general plans and specifications of the work. Construction started on October 1st, 1913 and the works were completed in March, 1919.

The consulting engineers recommended the Lake of the Woods source for three main reasons, as follows:

(1) This source could provide an inexhaustible supply of water.

(2) The quality of the water was excellent and came from a virtually uninhabited area.

(3) The average lake level was 290 ft. higher than the reservoirs in Winnipeg.

The importance of the last mentioned factor can be illustrated by stating that between the start of operations in 1919 until the summer of 1951, every gallon of water used in this area was delivered almost 100 miles by gravity and from 1951 until this year, pumping has only been required during peak summer periods.

The gravity flow section is for the most part of plain concrete, of horseshoe cross-section varying in size from 6.35 ft. x 5.35 ft. to 10.75 ft. x 9.0 ft., extends westward from the Intake for about 80 miles and has a capacity of 85 m.g.d. From the west end of this horseshoe shaped section there extends a depressed section of reinforced 8 ft. diam. concrete, 4 miles long, continuing the capacity of 85 m.g.d. to Deacon, the site originally chosen for a future 250 million gallon reservoir. Between Deacon, about 8 miles east of St. Boniface, and the surge tank and booster pumping station located on the east bank of the Red River, there are approximately 49,000 lineal feet of 66 in. concrete pressure pipe, having a capacity of about 50 m.g.d. Fig. 1 shows the plan and profile of the aqueduct.

A 60 in. cast iron pipe crosses the Red River in tunnel and a 48 in. Lock Joint reinforced concrete pipe, approximately 12,000 ft. long, extends through the City of Winnipeg to its reservoirs at the western terminus. This latter pipe, depending on the quantity of water being used east of the Red River and at the James Avenue Pumping Station, has a capacity of 28.5 m.g.d. under gravity conditions or between 38.5 and 42 m.g.d. when the booster pumps are being used.

The original design of the aqueduct was such as to develop its full capacity in several stages as demand required. (See Fig. 2). It was originally estimated that the booster pumping station would have to be built about 1922 when Winnipeg's average daily consumption reached approximately 25 m.g.d. It was also estimated that the second branch aqueduct would be required about 1930 when the demand approached an average daily consumption of 35 m.g.d. However, following the first Great War and the construction of the Panama Canal, Greater Winnipeg's population remained almost constant and did not resume its growth until the Second War, which meant that these additions were not required until very recently

Since 1948 the original plan has been under periodic review. In 1950 a booster pumping station was constructed adjacent to the surge tank to completely develop the first 66 in. pressure line from Deacon to Winnipeg. In 1952 a report, made jointly by engineers of the City of Winnipeg and the District, indicated that a second branch aqueduct would be required by 1963 and suggested a route for this line. Right-of-way privileges were secured by means of an agreement with the City of Winnipeg Hydro Electric System. A further review early in 1957 indicated that the second line would be required by about 1960.

Preliminary Design

The future organization of Greater Winnipeg's water supply has been in a state of uncertainty because it, like other area wide services, has been under review by the Greater Winnipeg Investigating Commission since 1955. The Commission's report was not brought down until January, 1959 and action on it was not taken until the 1960 Session of the Legislature. As a result, an additional burden was placed on the District's design engineers since all of the facilities to be constructed would have to be capable of functioning efficiently whether the organization of water supply remained as at present or whether it was changed to a completely integrated system under a single amalgamated city or some form of metropolitan government.

Nevertheless it was clear early in 1957 that the additional facilities would be required by 1960 and that design and construction would have to proceed almost immediately if the District was to be in a position to deliver the water required into the Greater Winnipeg area at that time. Accordingly, detailed design work was proceeded with, including survey work and soil investigation in the field. Investigation of the proposed crossing of the Red River, including soil and rock borings, had been made during the winter of 1955-56.

A preliminary report of the complete work to be undertaken was presented to the Board of Commissioners on December 13th, 1957. The report included detailed outlines of the various projects which would have to be constructed, a list of items which would require additional investigation, an estimate of the cost and the time table for the calling of tenders and completion of construction. On the suggestion of the General Manager, concurred in by the Commissioners and the Administration Board, a copy of the preliminary report was submitted to Messrs. Alvord, Burdick & Howson, Consulting Engineers of Chicago, for review. The general scheme was approved by the Consultants and a number of very valuable suggestions were made which were incorporated into the final specifications.

The District's Consultants on soil investigation, Messrs. Baracos and Marantz of Winnipeg, were also of considerable assistance in working with the District and with the Chicago Consultants. Borings and soil samples were made under their direction along the entire route of the pipeline to obtain data on which to base pipe loadings and trench dimensions and to detail bedding and backfill procedures.

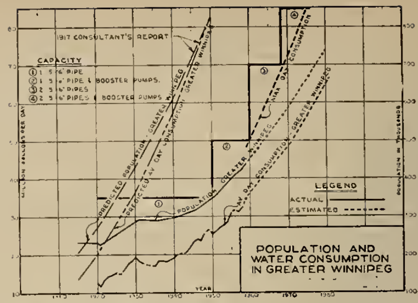


Fig. 2. Population and water consumption in Greater Winnipeg. Curves on left from 1917 Consultant's Report.

General Design of Pipeline

Route: In the original works an arrangement of three 60 in. valves was installed for a proposed reservoir at Deacon, Mile 12.5. These valves permitted a connection to be made fairly readily for the second branch aqueduct at this location, without interrupting the flow. The City of Winnipeg, after consultation with the District, had acquired land for a new reservoir at the south limit of the City of Winnipeg, which location fixed the westerly terminus of the new pipeline. A general investigation was made of several alternate routes between these two points, with detailed planning and cost estimating being made for two alternate routes. (See Fig. 3)

The first route followed the Slave Falls Transmission Line Right-of-Way owned by the City of Winnipeg Hydro Electric System and traversed open prairie for almost its entire length. Very few municipal services existed along this route and no great difficulty was apparent in crossing municipal roads, highways or rail lines. The only extra land purchased was at the crossing of the Seine River in order to permit a better crossing location.

The second route, while more direct and appreciably shorter, passed through the built up areas of St. Boniface, St. Vital and Fort Garry and presented considerable difficulties with location because of existing water, sewer, gas services and pavements. The banks at the crossing of both the Red and the Seine Rivers were more unstable on this route than they were on Route 1. Studies indicated that the use of this route would increase the cost, cause greater inconvenience and disruption and take longer to construct. There was, however, the advantage of a slightly greater hydraulic capacity using this route. After weighing all considerations, Route 1 was selected and this choice was subsequently confirmed by the District's Consulting Engineers.

Design Capacity and Pipe Size: The Red and Assiniboine Rivers divide the Greater Winnipeg area into three sectors, each of which uses about one-third of the total amount of water presently being delivered to this area. From a future population distribution study, based on a forecast made by the Metropolitan Planning Commission, the same ratio will prevail in 1981. From this, it would appear that additional reservoirs and pumping stations will eventually be required on the east side of the Red River and provision was made for this in determining the capacity of Branch II* After a detailed consideration of future water requirements in this area, it was decided that Branch II should essentially duplicate the capacity of Branch I.

The next problem was to determine whether it would be more economical to satisfy the needs of the new South Winnipeg Station by gravity alone or whether booster pumping station facilities should be installed. The size of pipe required to deliver 50 m.g.d. by gravity to the new reservoir is 72 in. diam., using a C value of 140. Various combinations of smaller pipe sizes and continuous or intermittent booster pumping were considered but it proved to be more economical to construct the entire line with 66 in. diam. pipe to deliver 35 m.g.d. by gravity initially, with provision for the future installation of a booster pumping station to increase this capacity to 50 m.g.d.

However, serious consideration was given to constructing the booster pumping station concurrently with the pipeline for use in the event of a break in the existing Branch I. This line has now been in service for more than 40 years and it seems prudent to assume that difficulties with its operations may arise at any time. This has always been of particular concern to the District as the City of St. Boniface, the Town of Transcona and the Municipality of St. Vital perform their own domestic water pumping but have no reservoirs, and are therefore entirely dependent upon Branch I remaining in service for their water supply.

It was found on investigating this problem that if a break occurred in Branch I so that no water was available to the City of Winnipeg by that Branch, the maximum day's demand for that City and the municipalities served by Winnipeg could be satisfied from storage and from Branch II for about three days. By restricting water use to 42 m.g.d., the 1976 estimated average daily demand, water could continue to be supplied for up to 15 days by utilizing storage capacity. St. Boniface, Transcona and St. Vital would, of course, have no water available.

It was felt, therefore that there was no immedate justification for the capital expenditure, together with the maintenance and standby electrical charges which would be incurred by the construction of the booster pumping station on Branch II at this time. However, connections are provided in the pipeline so that the construction may be undertaken readily at any time.

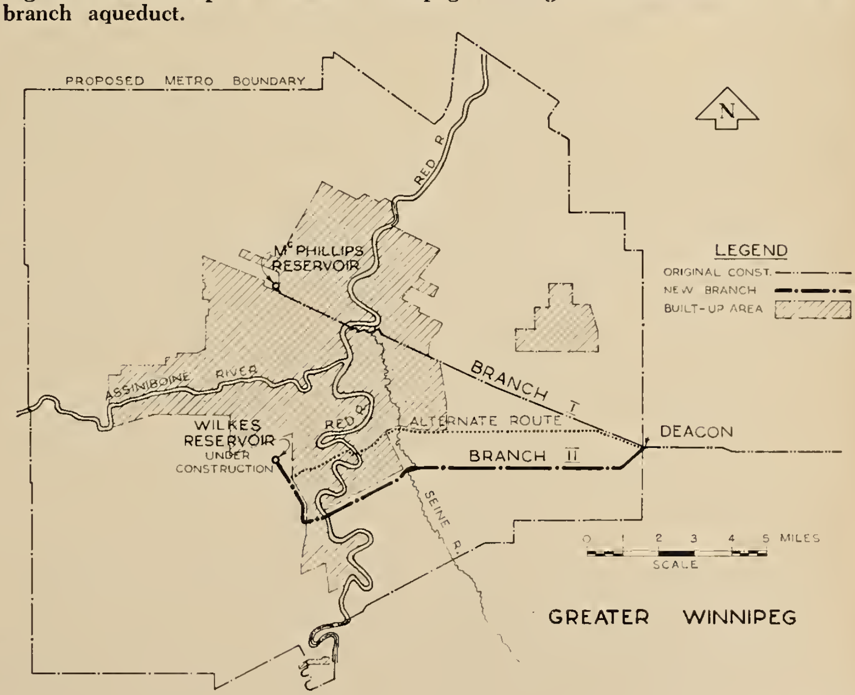
Type of Pipe: Having determined the route location and the pipe size, the next problem was to decide on the type of pipe to be used. The 66 in. section of Branch I was constructed of Lock Joint type reinforced concrete steam cured pipe made from Portland cement and the only serious difficulty that the District has experienced has been with the failure of the crimped copper expansion joints. This difficulty has been overcome with modern concrete pressure pipe which utilizes a steel ring and rubber gasket joint which permits some movement of the pipe.

In the preliminary report on Branch II, the District's Engineers stated that while both steel and reinforced concrete pipe has been used fairly extensively and successfully in long aqueducts, their first choice, based on local experience, was reinforced concrete pipe with rubber ring joints of the Lock Joint type. However, they recommended that bids also be called for steel pipe to ensure that no appreciable saving could be made by the use of this alternative. This recommendation was subsequently concurred in by the District's Consultants who have had extensive experience in pipeline work and they assisted in the preparation and gave final approval to the pipe specifications.

Concrete Pipe: In the detailed design of the pipeline, it was necessary to consider the several types of reinforced concrete pressure pipe. The design head of Branch II had been established at 100 ft and for this particular head, it is common practice to use one of the following types of pressure pipe: reinforced concrete pipe, non cylinder type, not prestressed, A.W.W.A. C-302; or reinforced concrete pipe containing a steel cylinder within the concrete wall yet not prestressed, A.W.W.A. C-300; or concrete pipe containing a steel cylinder in a concrete core, around which is wound prestressing wire, A.W.W.A. C-301. After considering cost, trench dead loads, traffic loads, probable leakage and manufacturing difficulties, it was decided to specify the latter.

The use of prestressed concrete pipe has become fairly common and the usual advantages of prestressed concrete apply. Prestressed concrete

Fig. 3. Outline map of Greater Winnipeg showing alternate routes for second branch aqueduct.



*For simplicity in this paper:
Aqueduct will refer to 85 m.g.d. pipeline East of Deacon.
Branch I will refer to original pipeline West of Deacon.
Branch II will refer to 66 in. pipeline now under construction.

pipe in this size range utilizes a continuous water-tight-steel cylinder, embedded in a concrete core which is wound with high tensile wire so that the concrete is in compression under all design loads. Design formula for this type of pipe have been developed with extensive use of empirical data otbained by pipe manufacturers. Comprehensive limits to the design have been established by the American Water Works Association and deal with normal hydrostatic pressure, water hammer, trench dead loads, live loads and impact.

While the terrain along the route of Branch II is fairly flat, there is some difference in depth of cover over the pipe. It normally ranges from the minimum cover of 5 ft. to about 7 ft. but in some sections, particularly under railway crossings and where the pipe is depressed beneath the Seine River, cover ranges up to about 25 ft. Since the pipe was being laid on a Hydro right-of-way and a patrol road was being constructed closely parallel to the pipeline, the pipe was required to withstand H-20 traffic loading simultaneously with full hydrostatic pressure. A table of minimum acceptable three-edge bearing strengths for various depths of cover was set out in the specifications and the pipe manufacturer was required to design and submit to the District for approval, various classes of pipe to meet these loading conditions.

Similarly, it was important that the steel pipe alternative have sufficient wall thickness to withstand the superimposed loads without "egging" and destroying the bond between the cement mortar lining and the inside of the steel shell.

Sulphate Resistant Cement: The selection of the type of cement to be used for the concrete pipe was another problem which had to be given very careful consideration. It is general practice in the Winnipeg area to use Type V sulphate resisting cement for all subterranean concrete work. It is interesting to note here that disintegration of the concrete in the 96 in. pipe of Branch I discovered in the first year or so after construction, resulted in the commencement of a research program to find more suitable cement which subsequently led to the commercial development of sulphate resisting cements by the Canada Cement Company.

In the construction of Branch I, an underdrain had been installed in the trench during the laying of the 66 in. pipe to provide drainage and to aid construction. On the discovery of the damage to the 96 in. pipe which proved to be due to heavy concentrations of soil sulphates between Miles 13 and 17, these underdrains were extended to lower the ground water table in the immediate vicinity of the pipe in order to minimize the effect of the alkali water. Periodic inspections have indicated that this solution has been quite effective in preventing further disintegration.

Soil samples taken over the route of Branch II for sulphate analyses indicated that concentrations ranged from 25 p.p.m. to 1123 p.p.m. based on 10% aqueous acid extraction. The use of alkali resisting cement is recommended wherever sulphates exceed 350 p.p.m. The difficulty with soil sampling is that the high sulphate concentrations occur in isolated pockets so that random sampling can only give a general indication of the soil sulphate level.

After weighing carefully all considerations, it was decided to specify Type V sulphate resisting cement for the new pipeline, even though this increased the estimated costs by 2%. This was more effective than providing a continuous underdrain over the 12 mile length, and considerably cheaper.

Steel Pipe: It had been decided to call for alternative bids using steel pipe to make sure that no appreciable saving in cost could be made using this material, and careful study was given by both the District's Engineers and the Consultants to make sure that any such alternative would be equivalent in all respects to the concrete pipe specified.

After analyzing wall thicknesses, loading and soil conditions, flow coefficients, construction and installation procedures, particularly under cold weather conditions, it was decided to specify steel pipe (A.W.W.A. C-201) with half inch wall thickness, coated with coal tar enamel and wrapped with double bonded fibrous glass mat and asbestos felt (A.W.W.A. C-203) and cement mortar lined in place (A.W.W.A. C602) as an equivalent alternative to the prestressed steel cylinder pressure pipe.

Trench Design: Because of the influence of external loads on the design of the pipe and the three-edge bearing strengths specified, it was necessary to carefully review the trench width and shape with the District's Soil Consultants and establish trench dimensions. The specifications required that vertical trench walls be maintained in the pipe zone. Trench width was limited to not less than 18 in. nor more than 24 in. greater than the outside diameter of the pipe.

The Red River Valley clays are subject to very considerable volume change with variation of moisture content. The specifications therefore required that the bottom of the trench could not be left exposed for any length of time following excavation and the maximum length of trench ahead of the pipe laying was limited to 300 ft. A 6 in. layer of granular material was specified for the bottom of the trench to provide proper bedding.

Some flexibility in the pipeline was also desirable to take care of differential soil movement, as well as temperature change, since the water temperature varies from 35 to 72° F. The Lock Joint type of joint consists of a round rubber gasket compressed between bell and spigot joint rings with cement grout being poured in both inside and outside joint spaces to protect the steel rings from corrosion. This provides some degree of flexibility but consideration was also given to using a paraplastic material instead of cement grout as a joint filler. The City of Chicago, among others, uses this procedure. However, since the pipe suppliers indicated some reluctance, it was decided to use the conventional cement grout.

Due to the known difficulties in compacting local clays, granular backfill material was specified to a height of one foot above the centre line of the pipe. From this point, excavated material was permitted as backfill but it was required that this material be placed in layers not more than 6 in. thick with each layer being tamped in place for a height of 3 ft. For the balance of the backfill, the Contractor was allowed to compact excavated materials in place, using a light crawler tractor in the trench. This backfill was to be brought to a height of 2 ft. above the original prairie grade to allow for subsidence.

Surge Protection and Overflow: A combination pump well and surge tank was provided on Branch I near the site of the booster pumping station on the east bank of the Red River and this has operated without any difficulties. Considerable study was given to the problem of surge in Branch II. The City reservoir is to be operated as a balancing reservoir so the inlet valve should not be manipulated very often, and by limiting the speed of the valve, no serious surge will occur. Preliminary studies indicated that even when the booster pumping station is constructed and in operation, surge pressures resulting from a power failure or pump stoppage can be held below the design strength of the pipeline and therefore no surge well was provided in the initial construction.

The existing surge tank on Branch I also serves as an overflow during periods of low demand west of the Red River crossing, but an overflow weir at Mile 17 is an additional control point for wasting excess water when the demand is low. This waste water is conveyed to the Seine River through an 11 mile long offtake ditch which causes considerable difficulty and maintenance expense, particularly during the winter, when intermittent spilling fills the ditch with ice.

To obviate this difficulty, a automatic spill valve was installed several years ago in the booster pumping station. This consists of an 18 in. butterfly valve positioned by an air cylinder, actuated by a pressure sensing device. This valve automatically holds the hydraulic grade at the booster station to a predetermined level, corresponding to the crest of the overflow weir at Mile 17 for a given flow rate. A similar device is being installed at the east tunnel shaft on Branch II. The valve and chamber are so arranged as to provide overflow to the Red River when it is below flood stage. When the river is in flood and the valve chamber is inundated, it will be possible to seal off the piping so as to prevent contamination of the potable water supply during these times of high water.

Valves and Meters: Only two main line valves were installed in Branch II. The first was a butterfly valve installed at Deacon to regulate the flow in Branch II. A second, an isolating valve, was installed immediately upstream of the Red River Crossing. Provision was also made at the location of the future booster pumping station for the eventual installation of an automatic valve which will serve both as surge relief and as a device to divert the flow through the new pumping station once the pumps are up to speed.

Automatic vacuum breaking and air release valves are installed at high points on the new pipeline. Each installation consisted of duplex mounting of 6 in. air valves, and 4 in. manual gate valves are also provided for the release of large volumes of air whenever the aqueduct is being charged.

Two long form Venturi meters were installed in the original aqueduct in 1919 at Deacon. Both are constructed of monolithic concrete with bronze throat and piezometer ring. The one located upstream of the branch measures the total flow in the main portion of the aqueduct and the other smaller Venturi measures the flow in Branch I. By installing new registers and electric flow transmitters at Deacon, it will be possible to record and integrate the flow in each branch of the aqueduct, as well as in the main section. Provision has been made for telemetering these readings to a central control station whenever required.

As take-offs will eventually be made at various locations along the line for other municipalities, it was necessary to install a metering device at the entrance to the City of Winnipeg reservoir. Studies were made of the various types of metering devices available, comparing accuracy, head loss, maintenance, construction difficulties and first cost, resulting in the choice of an orifice plate. A stainless steel concentric orifice plate was installed at Station 3+00, together with a low head type of meter and an electric transmitter which will provide an indication and integration of flow to the City of Winnipeg high level pumping station.

Guarantee of C Value: The carrying capacity of any pipeline varies with the frictional resistance (coefficient C) which is dependent upon the smoothness of the pipe interior and the quality of workmanship used in laying the pipe and making the joints. In the case of Branch II this factor is unusually important since the line is a low head pipeline. For example, a decrease in capacity of 100,000 g.p.d. will result from each additional tenth of a foot loss of head.

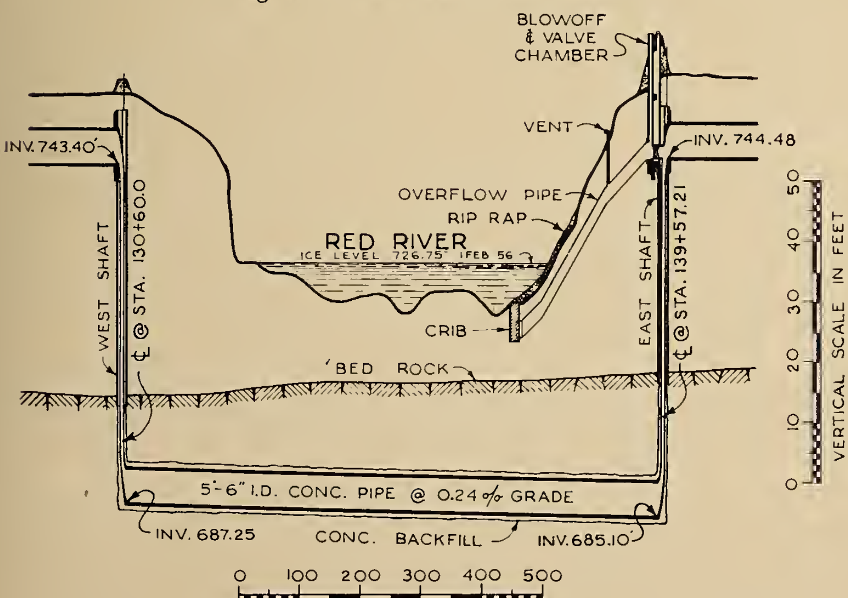
For this reason, a rather unusual procedure was followed in writing the specifications. Bidders were advised that the District had designed this pipeline based on a Hazen & Williams C value of 140 and that they would be expected to construct the pipeline to meet this requirement. On completion, the District would engage a competent independent water flow testing organization to make acceptance tests and any failure to meet the required C value would result in a deduction from the lump sum contract price of $42,000 for each point or major fraction thereof by which the C value falls below 140.

The figure of $42,000 was established by evaluating the loss of capacity resulting from the lower C value on a pro rata basis with the design capacity and the estimated total cost of Branch II. The specifications state that no bonus shall be paid should the C value exceed 140. The report of the independent testing organization would be final and binding on both parties. Corporation cocks are installed at various locations along the pipeline to facilitate the use of Pitometer equipment in making these tests.

It is unfortunate that not many long pipe lines of large diameter are tested immediately following completion to provide more data. We do not know of any other instance where the above mentioned method of guaranteeing the friction factor has been used. It can, of course, only be used equitably if one contractor is responsible for both the supply and installation of the pipe.

Method of Calling for Tenders: It has generally been the District's practice to call separate tenders for material and for installation. In the case of Branch II, however, it was decided, after serious consideration of the problems involved, to call tenders for a completed pipeline job, commonly referred to as a "turnkey" contract. This method had been used fairly extensively, particularly in the United States and has several advantages, including the elimination of divided responsibility between the pipe manufacturer and the installation contractor regarding completion date and progress of the work, as well as the quality and acceptability of the fin-

Fig. 4. Profile of Red River Tunnel.



ished pipeline, thus permitting the guarantee of the C factor.

This procedure was recommended to and agreed upon by the District's Administration Board.

A great deal of interest in the project was exhibited by contractors all across Canada and by several in the United States. More than 75 sets of tender documents were issued and subsequently seven tenders were received. Competition between the steel pipe manufacturers and the concrete pipe manufacturers was particularly keen. Seven bids were received, based on the use of reinforced concrete pipe as specified, varying in total from $3,812,571.87 to $4,533,805.00. Seven bids were also received, based on the use of steel pipe, which were in accordance with the specifications and ranged from $4,093,827.00 to $5,840,000.00. The low tenderer on steel pipe also submitted four alternative tenders, each at variance with the specifications in certain respects. The lowest informal tender was for the amount of $3,704,484.00 and was based on reducing the steel plate thickness, deleting one of the double bonded wrappings specified and substituting a bituminous enamel lining for the cement lining specified. Informal tenders were naturally not considered and a contract was awarded to the low bidder using concrete pipe.

Construction

The contractor moved in a temporary pipe manufacturing plant and set it up on District property in St. Boniface. The winter of 1958-59 was an unusually severe one with very heavy snowfall in mid-November, but the Contractor, with excellent management, was able to pour his footings and erect his plant in time to produce the first pipe on schedule by April 1st, 1959. A total of 4,000 pipes, each 5 ft. 6 in. in internal diameter, 16 ft. long and weighing 11½ tons was produced by October 31st, 1959.

As mentioned, prestressed embedded cylinder concrete pipe (A.W.W.A. C-301) was used. Manufacture consisted of rolling and welding 16 gauge plate into cylinders to which were welded forged steel bell and spigot ends. Each cylinder assembly was hydrostatically tested to 43 p.s.i. (sufficient to stress the steel to 25,000 p.s.i.), then centred in a vertical mould into which 4,500 p.s.i. concrete was poured. After steam curing, this 5 in. thick core was rotated and wrapped with No. 6 gauge steel wire having an ultimate strength of 190,000 p.s.i. The pitch of the wrap was varied according to the class of pipe being produced. In all, six different classes of pipe were designed to cope with the varying cover over the pipeline throughout its length. For instance, Class A pipe was designed to withstand a 5 ft. backfill load, Class B was designed to withstand a 6 ft. backfill load and Class F was an extra heavy pipe designed to withstand up to 25 ft. of over-burden and was used in the crossing beneath the Seine River.

The local soil is extremely active, causing graphitic corrosion of cast iron, as well as affecting Portland cement concrete and steel. Special consideration was therefore given to the protection of the high tensile wire. A mortar coat of 1⅛ in. thickness was asked for instead of the normal ⅞ in. Since it was very difficult to check this thickness once the coating had set, the District assigned an inspector solely to this operation. By using a penetration gauge he was able to check the thickness as the mortar was brushed on. If too thin, additional material was brushed on before the pipe was removed from the machine.

The services of the National Testing Laboratories of Winnipeg were engaged to carry out a rigid inspection of all phases of the pipe manufacture. One pipe from each day's run was hydrostatically tested to 100 p.s.i. and not one of the pipes so tested exhibited any signs of leakage or cracking. In addition, the specifications required that the Contractor demonstrate the adequacy of his design for each of the classes of pipe by carrying out three-edge bearing tests to destruction on one pipe from each class. The short sections of pipe so tested proved the design was more than adequate to meet all conditions and the designs were therefore accepted.

The District had a Canadian materials preference clause in the specifications and it is interesting to note that with the exception of the steel joint rings and rubber gaskets, all other material used in the pipe manufacture was of Canadian origin.

One problem that arose and which gave the District and the Contractor considerable concern was that of small imperfections to the inside of the pipe wall, in the form of pock marking. After exhaustive investigation, it was decided that some degree of pock marking was inevitable in any concrete work where smooth steel forms were used. However, it was found that the prevalence of pock marks was considerably reduced by varying the fineness modulus of the aggregate until the optimum was reached, by adjusting the form vibrators until the maximum amplitude of vibration was reached and by exercising very close control over the time taken by the men to fill each steel mould. It was found that if the moulds were charged slowly at rates less than one vertical foot per minute, better quality pipe resulted.

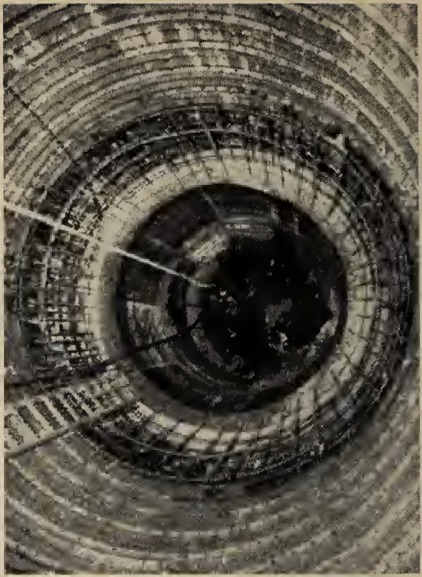


Fig. 5. Stripping forms from concrete shell east shaft, Red River Tunnel prior to commencing rock excavation.

The first pipe was laid on May 22nd, 1959 and pipe laying was essentially completed, other than for certain connections at Deacon and miscellaneous structures, by Christmas, 1959. To meet the District's rigid specifications for vertical trench walls, the Contractor devised an ingenious steel box or sled which was put in the trench wherever bad ground was encountered and slid along as each pipe was laid.

Another departure from standard practice was the method used by the Contractor to compact the granular backfill material. This material was placed uniformly on either side of the pipe to the required level of one foot above the centre line of the pipe and then jetted with a one inch water pipe and vibrated with a heavy duty concrete vibrator. This provided very good consolidation and was used even in the late fall with the onset of cold weather.

Notwithstanding the abnormally wet spring, summer and fall, with rainfall of 21.85 in. compared with the normal of 15.52 in., the Contractor was able to maintain exceptionally good progress. The best day of pipe laying saw 63 pipes installed and backfilled, or a total of 1,008 ft. of pipe laid. This was done with only one spread working.

The railway companies insisted that the pipe be encased where the line passed under all existing tracks. 96 in. tunnel liner was installed ahead of the pipe laying crew. The same method was used in crossing under two paved trunk highways.

Very few municipal utilities were encountered but those that were had to be relaid so as to permit the installation of the large pipeline. Water mains varying in size from 6 in. to 14 in. were relaid as were sewers varying from 8 in. to 30 in. The Seine River was crossed by a depressed section, using concrete pipe laid within steel sheet piling which was intended to aid the construction as well as serve to prevent any future scour of the river bed. Because of the wet season, abnormally high flows prevailed throughout the summer and it was not until late November that the Contractor was able to divert the stream and lay the pipe. Once flows had dropped to normal, no great difficulties were encountered.

The contractor was permitted to continue working during the cold weather, but heated backfill material was required and extra precautions to warm the ends of the pipe as well as the interior were required to permit mortaring of the joints. A small crew worked throughout the winter of 1959-60 completing miscellaneous concrete structures and the connection to the main aqueduct at Deacon. Pressure testing will be completed this spring but due to the fact that the City of Winnipeg reservoirs and pumping station will not be available until mid-summer of 1960, it will not be possible to complete flow and acceptance tests until that time.

As mentioned, weather conditions were abnormal with precipitation being much heavier and more frequent than normal. However, both the prime contractor and the pipe laying sub-contractor, by bringing in top flight supervisory personnel and adequate equipment and by excellent job organization, were able to maintain their schedule. All concrete pipe for the line, as well as for the Red River Tunnel, and some 2,750 ft. for the City of Winnipeg reservoirs were manufactured by October 31st, 1959. The contract called for 60,000 ft. of pipe to be laid by November 15th and the job completed by July 1st, 1960. Actually the job was completed in March, 1960, with the exception of testing and cleanup work.

Red River Tunnel Crossing

Design: Branch I crosses the Red River by means of vertical shafts 75 ft. deep on each side of the Red River, joined together by a horizontal tunnel through the limestone bedrock underlying Winnipeg. 60 in. diameter cast iron pipe was installed in the vertical shafts and in the horizontal tunnel, with the space between the exterior of the pipe and the tunnel backfilled with concrete grout. Since this crossing has proven eminently satisfactory, having been in continuous operation without any maintenance whatsoever for more than 40 years, it was felt that the same procedure should be followed again. It was nevertheless decided to consider the only two other alternatives:

(1) a pipe crossing laid on the bed of the river,

(2) a pipe crossing supported on a bridge.

The Greater Winnipeg Sanitary District and the City of Winnipeg have constructed numerous crossings of both the Red and Assiniboine Rivers by laying pipe, usually cast iron, on the river bed. However, particularly in recent years, there have been numerous failures which have been caused by the movement of the banks and in some cases, scour of the river itself. Recently the practice has been adopted of using steel pipe, bedded in a trench, with approximately 4 ft. of cover. The Winnipeg & Central Gas Company has recently installed similar crossings. However, the largest of these pipes has been 24 in. in diameter and when the size of this particular pipe was taken into consideration and the fact that this would form one of the two supply mains to Greater Winnipeg across the Red River, it was felt that this method was not suitable.

The practice of supporting mains on bridges has been used fairly generally and in some cases, special bridges have been built for this purpose. Mr. William Walkden, M.E.I.C., was asked to make a preliminary report on such a bridge for the District. This report indicated that without taking maintenance costs or possibility of damage into consideration, the initial capital cost would result in very little, if any, saving over a tunnel crossing in bed rock. However, when the final hydraulic gradient was developed, it ruled out the bridge crossing since the pipe elevation to meet high water flow conditions in the river, as well as to clear navigation, would have had to be at an elevation only slightly under the hydraulic gradient line at maximum design flow, which could have meant syphoning and difficult operating problems. It was then decided to base the design on two vertical shafts and a rock tunnel. (See Fig. 4)

The original 20 ft. diam. shafts had been constructed by casting reinforced concrete sections at ground level and sinking them in place. This method had also been used successfully in constructing the surge well at the Sewage Disposal Plant and by the City on a somewhat similar water main installation. The District therefore suggested a similar method but did permit contractors to bid on other alternatives in addition to this method. As will be described later, the successful contractor subsequently asked for and was granted permission to use a different method of constructing the shafts.

As a contract had been awarded for the construction of the pipeline proper by using reinforced concrete pipe, it was felt that this would probably prove cheaper for the tunnel crossing, but the specifications nevertheless did permit the steel pipe alternative. The lowest tender submitted for the crossing was based on the use of prestressed embedded cylinder concrete pressure pipe.

The cast iron pipe in Branch I had been grouted by pumping grout into the tunnel from pipes driven down through the river bed. In the specifications for the second branch, two alternatives were given and the contractors asked to quote on each of them. In one case, grout holes were to be provided in the pipes themselves, with the grouting being done from the inside. The alternative to this called for concrete backing to be placed around each pipe as it was laid. Subsequently the low bidder's figure for the second alternative was $18,000 less and the District accepted that procedure.

Diamond drill cores taken from the ice indicated that water would be encountered at certain elevations in the limestone. A tunnel profile was established which the District's Engineers thought should present the least difficulty with this water, but the Contractor was offered the option of lowering the tunnel centre line up to 10 ft. if he felt that this would mean more favorable conditions in the tunnel. Once construction was started and the east shaft had been sunk, the contractor decided to follow the line selected by the District.

Six tenders were received, ranging from $357,325.00 to $646,459.00, the contract being awarded to the lowest bidder. The bid was made on using the District's suggested method of sinking the shafts, but subsequently the contractor asked permission to use a modified method.

Construction: The contractor felt that it would be quicker to sink the vertical shaft, lining it with tunnel liner and grouting in behind the liner, then pour the required reinforced concrete shell from the bottom up. While the District had some qualifications about this method, particularly in regard to water, and felt that the original method was safer, the contractor was granted permission to use his proposed alternative. The shaft was sunk quickly, due to the novel method the contractor used. Seven 36 in. diam. holes were augered to bedrock and the remaining earth removed by clamshell bucket. Augering these holes saved a great deal of time and excavation in mucking the excavation. (See Fig. 5).

As had been feared by the District, a considerable quantity of water was encountered as the shaft entered the rock. In order to seal off this flow of water, the contractor felt it necessary to pour a thick mat of concrete, which was then pierced by 2 in. holes through which grout was pumped under pressure to seal off the crevices in the rock before excavation continued.

No great difficulty was encountered with the west shaft, which was excavated following a similar procedure as no water was encountered at the base of the west shaft.

The horizontal tunnel was driven as one heading, under atmospheric pressure from the east shaft westerly, advancing about 8 ft. per shift. The upper 3 ft. of the heading was in tight, white limestone but below this was a 2 ft. seam of fractured, water bearing red shale. This was underlain by 3 to 4 ft. of grey, highly fractured flow. No attempt to grout was made until the entire tunnel had been completed. Once the tunnel had been driven to a point beneath the base of the west shaft, a vertical shaft was driven up to complete the rock work.

The specifications required that the pipe be placed in the dry. As an attempt to reduce the flow of water, the contractor poured a primary concrete lining to seal off the fissured rock in the lower 4 ft. of the walls and confine the flow to drains in the floor, which was partially concreted. This was not sufficient to stop the flow of water completely and it was necessary to grout fairly extensively before the flow was reduced to the District's satisfaction.

Because of the nature of the rock and the way in which it was bedded, it was virtually impossible to eliminate overbreak, so that a tunnel roughly 9 ft. square resulted. Arrangements were made with the contractor to install a 24 in. water main in the tunnel, which could be used as a future high pressure feeder main crossing. (See Fig. 6).

Laying of the 5 ft. 6 in. concrete pipe commenced at the west shaft. Pipes were used to confine the water flow, while solid concrete was placed in the annular space between the outside of the pipe and the rock face by means of a Pendell pneumatic concrete placer. Periodically these pipe drains would be grouted off. One pipe was laid and backfilled with concrete before the next pipe was laid. In this way, the water was completely stopped and a satisfactory pipe laying operation was possible.

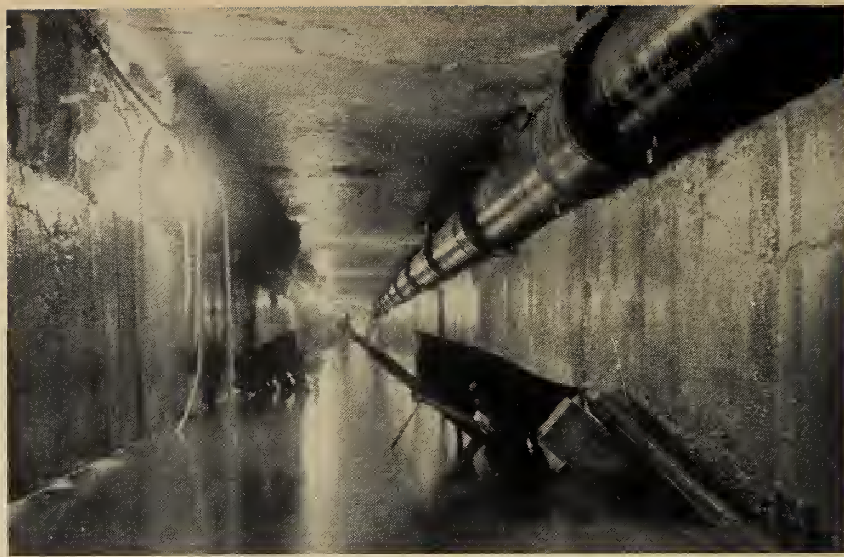


Fig. 6. Twenty-four inch cast iron pipe in place.

Work on the Red River Crossing commenced on February 23rd, 1959 and pipe laying was virtually complete by Christmas 1959. Concrete work around the top of the shaft and the valve chamber was completed in January and February of 1960, but testing of the completed crossing was deferred until the spring.

Indian Bay Low Lift Pumping Station

Necessity of Maintaining Lake Levels: The capacity of the gravity flow section of the aqueduct depends on the water level in Shoal Lake, as shown in Fig. 7. A level of 1058.3 is required to deliver 85 m.g.d. The District's records indicate that between 1918 and 1959, the lake levels fell below 1058.3 in 16 years and that in 1931 it fell to 1056, which would only permit delivery of 45 m.g.d.

Lake of the Woods drains into Lake Winnipeg through the Winnipeg River, the flow being controlled by a dam at Norman, near Kenora, Ontario. As the Winnipeg River is still the major source of power for Manitoba and since Lake of the Woods is an international body of water, the matter of lake levels is of great importance. As long as the levels are between 1056 and 1061.25, control lies with the Lake of the Woods Control Board, a Canadian body with representatives of the Federal Ontario and Manitoba Governments. However, if either of these limits is exceeded, control passes to the International Joint Commission.

Both the Manitoba and Western Ontario power systems now have substantial thermal generating capacity which will allow more efficient use of the hydro sources of the Winnipeg River. New patterns of river flow regulations will probably evolve, resulting in lower average levels on Lake of the Woods. Consequently there is a good possibility that Shoal Lake levels will fall below 1058.3 much more frequently.

With the construction of the second branch aqueduct, the question of lake levels became a matter of prime importance and measures had to be taken to make sure that 85 m.g.d. could be introduced into the aqueduct at the Intake under all conditions.

While the Board of Consulting Engineers who were responsible for the design and construction of the original works did an outstanding job, making provisions for future additions to be constructed as demand required and as witnessed by the fact that our present projects could be fitted in some 40 years later without undue difficulty, they made no provision for the construction of a low lift pumping station to maintain the required 85 m.g.d., although they had considered the possibility of pumping at a later date to increase the flow to some 120 m.g.d. when required.

Preliminary investigation indicated two possibilities of assuring this required flow, as follows:

(a) the construction of a dam and lock at Ash Rapids in order to maintain the level of Shoal Lake itself above 1058.3.

(b) The construction of a low lift pumping station at the Intake to lift the required amount of water into the Intake, regardless of the level of Shoal Lake.

Ash Rapids Dam and Lock: The Lake of the Woods, including Shoal Lake, has a water area of 1,500 sq. miles with a drainage basin of some 27,700 sq. miles. Shoal Lake itself has a water area of 107 sq. miles with a drainage basin of 360 sq. miles. Shoal Lake is interconnected with the Lake of the Woods proper through a very narrow channel some 2,000 ft. in length known as Shoal Lake Narrows. The actual passage at either end of these narrows is very much restricted with a rapids being located on the eastern end. Preliminary survey work indicated that it would be quite feasible engineering-wise, to construct a dam at the latter location. However, a lock would also be required to permit navigation through it. This scheme would only be feasible if the drainage area of Shoal Lake itself was sufficiently large and could be depended upon to maintain a lake level of 1058.3 under all climatic conditions with a draw of 85 m.g.d. or more in the future. From original reports on the District's files, it appeared that there was some considerable difference of opinion on whether Shoal Lake alone could provide the water required. The District therefore requested the Water Resources Branch of the Provincial Government to make a study of this problem.

Pumping Station: While the construction of a low lift pumping station would be a relatively simple project in itself and would obviously permit any quantity of water to be pumped into the aqueduct under any conditions of lake level, there were certain problems involved, as follows:

(1) Only a limited amount of single phase power is available and this comes to the site over a 15 mile long line. Discussions with the Manitoba Power Commission indicated that the construction of a new transmission line from West Hawk Lake and the necessary ancillary construction would make this scheme economically impractical. Auxiliary power was therefore the only answer.

(2) No provision had been made in the design of the original Intake for the construction of a pumping station, and as three municipalities served have virtually no storage capacity, the flow of water could only be interrupted for very short periods.

(3) The pumping equipment itself would have to be very carefully chosen and probably specially designed since it would have to be capable of pumping quantities varying from 40 to 85 m.g.d. under heads which might range from 4 ft. to 9 ft.

A preliminary comparison of the various factors involved indicated that the construction of a pumping station at the Intake would prove to be the most suitable scheme. The report received from the Water Resources Branch indicated that from the little information available, it was doubtful that the required lake elevation could be maintained in a prolonged dry period. Aside from the construction and operational problems which would entail staffing and operating the locks at an extremely remote location, the Ash Rapids scheme would entail considerable negotiation with Provincial, Dominion and United States authorities. It was therefore decided to proceed with the design of the low lift pumping station at Indian Bay.

As mentioned, the construction work had to be carried out and connected with the existing facilities without interrupting the flow of water for more than a few hours. Furthermore, it was not possible to interfere with the flow for even this short period during peak flow conditions, between May 15th and October 30th, so that the timing of construction was one of the important factors to be taken into consideration in the design. The existing gate house, shown in Fig. 8, consists of a submerged intake to prevent flow of ice into the channel during the winter months. From this Intake the flow divides into two channels, passing through trashracks just as it enters the gatehouse structure. The water then passes through screens and through control gates before flowing into the aqueduct proper. The thoroughness of the design by the original engineers is indicated by the measures which were adopted to prevent debris, leaves, grass and other materials getting into the Intake. This was accomplished by locating the intake opposite a small island several hundred yards out in Indian Bay and providing two gravel and rock dykes which extend out 200 ft. into the Bay.

Initially, consideration was given to the construction of the pumping station as a separate structure ahead of the intake itself, in the area between the two dykes mentioned above. Investigation indicated that this was not the best solution, chiefly because the dykes themselves had been constructed of loose rock material and there was some doubt of their stability under flow with differential heads of up to 10 ft. Furthermore, there could be construction problems in coffer damming while maintaining a flow of water into the aqueduct.

A location immediately north of the present intake structure was then

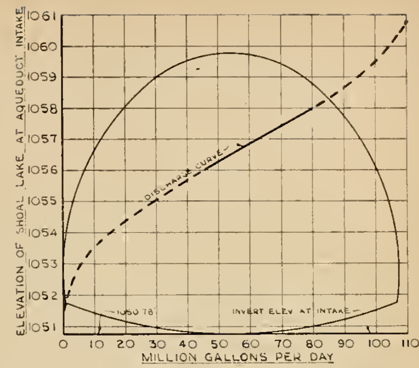


Fig. 7. Discharge capacity of Aqueduct.

considered and was finally adopted. Even here, however, there were a considerable number of problems to be overcome, chiefly that of diverting the water from both of the channels into the pumping station, through the pumps and back into those same channels, downstream from the existing gates. Since this total distance was only 132 ft., it meant that very careful design had to be given to the water passageways. A basic condition to be met by the pump manufacturers when tenders were called for the pumps was that they approve the arrangement of the pumphouse and passages.

Pumps and Prime Movers: Since the extreme low recorded water level for Indian Bay is elevation 1056.0 and since the hydraulic grade line required for a flow of 85 m.g.d. in the arch section of the aqueduct is 1058.3, a static lift of only 2.3 ft. is required. However, a designed low water level of 1055.0 was decided upon. Once the station design was worked out, it was found that it was necessary to have a static lift of up to 9.16 ft. at maximum pumping rate and extreme low suction well level.

Axial flow pumps were the obvious choice and a rather novel type was selected after a good deal of discussion with two manufacturers. This pump consists simply of a steel tube, belled out at the bottom, in which is mounted a propeller with the water flowing over a circular discharge weir.

As it was not economically practical to bring in a new electric power transmission line, diesel generators and electric motors were considered for drives, but after a good deal of consideration, were ruled out in favor of direct diesel drive. It was found that the speed of the diesels could be varied to regulate the capacity of the pumps over a sufficiently wide range without going to the added expense of adjustable bladed impellers, which had been considered.

It was felt that the installation of dual pumps was warranted, but due to the unorthodox nature and size of the pumping equipment, it was not possible to secure sufficiently accurate estimating prices on which to base an economic comparison. Tenders were therefore called for two sizes of pumps, with the District having the option of selecting any combination of the units tendered upon. Five tenders were received, none of which complied completely with the specifications.

The specifications were then revised slightly and tenders again called, with the result that four bids were received, three of which could be considered as formal tenders. After discussions with the two lowest tenderers, the contract was awarded for the design, supply and delivery of one 85 m.g.d. and one 60 m.g.d. pump, together with diesel engines and right angle drives, for the price of $88,680.00.

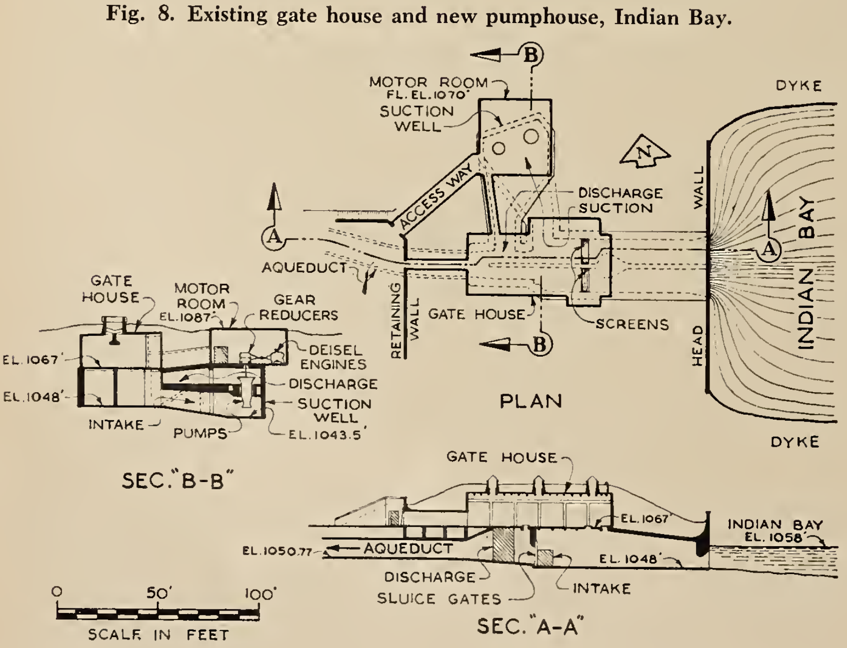
While the upper 9 miles of the aqueduct is designed to carry a flow of 120 m.g.d. with a 4 ft. surcharge on the arch, it was felt necessary to protect the unreinforced concrete section against any higher head. Overflow weirs were considered but due to the swampy terrain which the aqueduct traverses at this location, great difficulty would be encountered in keeping high water out of the pipeline during certain periods of the year. Electrode type high and low level recorders were therefore installed in the suction well and in the discharge flume, which will automatically shut off the prime movers in the event of an abnormal water level.

Mechanically Cleaned Screens: In the original construction of the Gate House, fixed water screens were installed. These screens have a maximum square opening size of 3/32 in. and each of the 10 sets of screen panels have to be removed by means of hooks and overhead cranes. The water is normally fairly clear but occasionally, during the spring and fall turnover of the lake, large quantities of weeds and debris are carried into the Gate House and cleaning of the screens becomes a considerable problem. The Intake staff consists of an Operator and Assistant and at these times of the year their enitre time is devoted to cleaning the fixed screens. The construction of Branch II and the installation of low lift pumps will result in increased flows and higher velocities which will aggravate this problem.

It was therefore decided to install travelling water screens at the same time as the new pump house was being constructed to house the low lift pumps. Two sets of 10 ft. wide mechanical screens are to be installed with screen openings of ⅛ in. square. Tenders were called for stainless steel, bronze or galvanized steel screens and stainless steel was selected as the most economical choice.

Because only single phase power is available at the site, it was necessary to install phase converters to provide three phase power to drive the 15 hp. turbine type wash water pumps. Single phase motors were also considered but because of the difficulty of securing hollow shaft single phase motors of this size, were ruled out. A standby generator was also installed which will be driven from the shaft of one of the diesel pump engines.

Fig. 8. Existing gate house and new pumphouse, Indian Bay.



Pump House Structure: Once the details of the mechanical equipment were available, the detailed design was prepared of the low lift pump house structure and tenders were called. Four tenders were received, with the contract being awarded to the lowest bidder at $190,576.00. Construction commenced on June 22nd, 1959. The pump house is situated in a solid rock ridge immediately north of the existing Gate House. Extreme caution had to be exercised by the contractor in blasting the rock, but nevertheless an unknown fault in the rock resulted in a rock shift which caused extensive damage to the north wall of the Gate House so that the roof had to be shored up and the entire wall repoured.

Conclusion

It might be worth repeating that the Consulting and Construction Engineers responsible for the original works did an outstanding job. The aqueduct has been serving Greater Winnipeg for more than 41 years and with the construction of Branch II, for which they had provided, will continue to serve more than half the population of Manitoba for many more years.

In the 46 years since work started on the aqueduct, the great majority of those responsible for this major project have passed away, but the authors would like to conclude by acknowledging the extremely valuable contribution made by three of the "originals" in the additions described in this paper:

Mr. Harold Shand, Asst. General Manager and Asst. Chief Engineer of the Greater Winnipeg Water and Sanitary District, who actively participated in both the design and construction of the additions and who was Office Engineer during the original construction.

Mr. Douglas L. McLean, Project Engineer on the construction of Branch II, who was Division Engineer on the original construction.

Mr. J. C. D. Taylor was mainly responsible for the design of the Low Lift Pumping Station before he passed away in December, 1958, and was Office Engineer on the original construction.

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THE KHULNA NEWSPRINT PROJECT

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The surge of nationalism sweeping the world today has brought into being many new countries. Most of these countries are underdeveloped and must be helped in their efforts to stabilize their economies and to raise their standards of living. Help has been given to these peoples by such organizations as the United Nations, the Colombo Plan of the British Commonwealth, and the International Co-operative Administration of the United States. In some instances, these agencies have helped by sending out experts in the fields of economics, education, and engineering, to name a few, to advise the peoples on how to deal with their particular problems. In other instances the aid has been solely financial, or has been a combination of both expert advice and financial aid.

Pakistan is one of the underdeveloped countries receiving aid from these agencies. The Khulna Newsprint Project is of particular interest, however, because the Pakistanis financed it from their national income with a minimum of outside aid, and engaged experts in the appropriate field to study and overcome the problems of establishing a newsprint industry from indigenous raw materials. That the enterprise was brought to a successful conclusion on schedule during times of both internal and external strife is a remarkable achievement and a tribute to the patriotic and tenacious spirit of the leaders of the Pakistan Industrial Development Corporation. No less is it a tribute to the drive and initiative of the Canadian Engineers and Contractors who were entrusted with the responsibility of establishing a new industry in Pakistan.

IT IS believed that the Khulna Newsprint Project in Pakistan is the only project for which a Canadian company has had complete responsibility not only for the engineering but also for the operation of an overseas pulp and paper enterprise. The responsibilities embraced all phases of the work from feasibility and economic studies to forest management, mill operation, and finally to sale of the finished product.

Not too much is generally known about Pakistan; some knowledge of the country, her people, and her history is essential to an understanding of the project.

Background

Geography: East Pakistan which lies north of the Bay of Bengal between India and Burma, occupies the delta of two great rivers, the Ganges and the Brahmaputra. When the rivers are in spate, there is a positive flow to the Bay of Bengal through the larger channels but during the dry season most of the waterways become little more than tidal sloughs. Khulna is a growing industrial town centrally located on this vast delta.

People: In an area of 60,000 sq. miles are crowded about 45 million people, predominantly Moslem — a population density of 775 people to the square mile. (By comparison, British Columbia occupies 366,000 sq. miles with 1.3 million people — a population density of 3.6 per sq. mile.) Life expectancy is 31 years and literacy is about 15%. About 95% of the people live in small villages of twelve to fifteen hundred people.

Transportation: Transportation is mainly by water on the numerous waterways that interlace the country. Most of the roads are little more than dirt tracks that become impassable during the rainy season. One system of the East Bengal Railway connects the Khulna area with the northwestern parts of the country. Another connects Chittagong, the only deep sea port, with Dacca, the capital city on the east. An anchorage for deep sea ships has been developed at Chalna on the Pusser River about 30 miles from the Bay of Bengal and 20 to 30 miles from Khulna. Shipments of materials and machinery from overseas to the central part of the country are off-loaded at Chalna to river barges which are towed to their destination by tug.

Climate: Temperatures range from about 55°F on a cold winter morning to as high as 110°F on a hot summer day. Prior to and during the monsoon rains that occur during the months June to September the relative humidities commonly range between 95 and 100%.

History: Since coming into being on the partition of the Indian Sub-Continent in 1947, Pakistan has been faced with tremendous difficulties in stabilizing her government and in rounding out her economy.

During partition people fled by the millions to the country of their choice — the Moslems to Pakistan; the Hindus to India. Some 3½ million people were killed and Pakistan alone had 7 million refugees. Many of the key administration positions at all levels of government and industry had been held by non-Moslems who fled to escape the carnage, with the result that many of the government offices and commercial establishments could not function.

Prior to partition, the area that is now Pakistan was wholly agricultural, and the industries dependent upon the resources of the area were located in the area that was allotted to India. In the early years the Pakistan government realized that industries utilizing the natural resources of the country would have to be established if favourable trade balances were to be built up and the country's position consolidated as an independent nation. To this end the Pakistan Industrial Development Corporation — a government sponsored body — was entrusted with the job of establishing basic industries. During the last decade about 10 or 12 basic industries have been established at a cost of about $190 million. The Khulna newsprint mill was a part of this overall industrialization program.

Feasibility Studies

Before a new industry can be established, several conditions must be satisfied. There must be an adequate supply of raw materials and a suitable process for converting them to a useful product; adequate markets on which to profitably sell the product; reliable facilities for transporting raw materials and finished products; and land available suitable for an industrial site — land that is close to the transportation facilities and to an adequate source of relatively pure water.

In addition to the physical requirements there must be sufficient capital to finance the enterprise and carry it into production.

The first phase of the engineering work embraced studies of these physical requirements. Some of the pertinent information was obtained from reports previously made by others and some was obtained by investigations carried out prior to and during construction.

Forest Resources: Of the three forested areas in Pakistan one lies in the Kagan Valley of West Pakistan. The other two are in East Pakistan, one on the delta of the Ganges River — an area known as the Sundarbans Forest, and the other in the Chittagong Hill Tracts, east of the Bay of Bengal. Bamboo in the Chittagong Hill Tracts had already been reserved for an existing sulphate mill and other species in this area were neither suitable nor in sufficient quantity to support a paper mill. Investigations proved that although the softwoods in the Kagan would be well suited to conventional pulping processes, they were inaccessible and their exploitation would be uneconomical. On the other hand the hardwoods in the Sundarbans were readily accessible and, in view of recent developments in hardwood pulping processes, looked more promising as an economic source of raw material. The Pakistan Industrial Development Corporation decided, therefore, to concentrate on the hardwoods in the Sundarbans.

Of the two dominant species, Sundri is dark in colour and heavy, and Gewa is light in both colour and weight and more suitable for pulping. Early surveys by the Indian Forest Service in 1931, inspections by the United States Technical Co-operation Administration in 1953, and advice from the East Bengal Conservator of Forests in 1954, placed the annual yield of Gewa between 35,000 and 47,000 air dry long tons, which would be sufficient for a mill producing 100 tons a day. The annual yield of Sundri, a possible fuel, was estimated at 100,000 air dry long tons.

In November, 1955, we commissioned engineers to analyze methods of extracting and transporting Gewa wood and to determine whether or not previous estimates of wood supply were correct. They were also to investigate the economics of extracting Sundri wood for fuel.

These studies were completed by June, 1956. The engineers found no reason to dispute the previous assessments of the amounts of Gewa and Sundri available and believed that the extraction methods currently in use could be expanded to ensure that the supply of Gewa would be sufficient to meet planned pulp mill needs. However, they recommended that the use of Sundri as a fuel be postponed until more suitable extraction methods could be developed to handle the large volume required. They also recommended that an independent detailed forest survey be conducted in the Sundarbans to provide the basis for a five year cutting program, and that steps be taken to increase the yield of Gewa. This survey was subsequently made and although the final results are not yet available the yield figures previously mentioned have been confirmed.

Process: Between the years 1948 and 1954, the making of suitable paper pulp from Gewa was investi-

Fig. 1. View of the Steam and Power Generating Plant with Water Treatment Plant in foreground.

gated in the leading experimental laboratories of the pulp and paper industry in the United Kingdom, Scandinavia and Germany. All met with limited success. In 1954, however, the New York State College of Forestry produced handsheets from mixtures of spruce sulphite and Gewa groundwood that were comparable to conventional newsprint. The need for further investigation was clearly indicated.

Under our supervision a comprehensive testing program was carried out by the U.S. Forest Products Laboratory at Madison, Wisconsin in the autumn of 1954. Papers were made from four different pulp types; chemi-groundwood, neutral sulphite semi-chemical, cold soda, and sulphate. The sulphate process was eliminated on the basis that it was not suitable for the small tonnages required. The cold soda process offered no advantage over the chemi-groundwood and neutral sulphite semi-chemical processes. As there was less mill scale experience on the cold soda process than the others the cold soda process was eliminated. The differences between the chemi-groundwood and neutral sulphite pulps were negligible insofar as quality was concerned. Although estimates showed no difference in the direct manufacturing costs they did show that the capital required for the neutral sulphite would be much higher than for the chemi-groundwood. Thus the chemi-groundwood process was determined to be best suited to the Khulna Project.

Markets: The market analysis was taken primarily from reports made in 1953 by the Technical Co-operation Administration of the United States and the Food and Agriculture Organization of the United Nations. These reports showed that the annual per capita consumption of newsprint in Pakistan was 2½ lb. as compared to 280 in Canada and 26 in Mexico, and that 30,000 tons of newsprint and printing papers were imported into Pakistan in 1952 at a cost of $8 million. They predicted that the population would increase to 88 million in 1962 and 100 million in 1972. Further they predicted that, with the accelerated educational program then in the planning stage, literacy would increase to 30% and 50% by the years 1962 and '72 respectively. Should these predictions come true, the demand for newsprint would be 23,000 and 56,000 tons, and for printings 41,000 and 99,000 tons by 1962 and '72, respectively. In the event that actual figures fell short of those predicted, it was believed that export markets could be found in the neighbouring countries of Burma, Ceylon, India and Malaya.

Fig. 2. General view of mill during construction. Note that concrete was delivered by mobile mixer but placed by "human bucket elevator".

Transportation: The abundant waterways of Pakistan proved very convenient for transport of wood from forest to mill. Logs were collected in bundles and in large rafts in the water and towing distances were reasonably short. Getting other materials and equipment to the mill and the finished products to West Pakistan was not quite so simple. Deep sea ships could only come up river as far as the anchorage, Chalna. Here the cargoes were transferred to river barges and towed to the mill. Finished paper is currently being shipped in the reverse manner to West Pakistan and by river steamer throughout East Pakistan. Should markets develop in India, a spur of the East Bengal Railway connects the mill with the distributing centre, Calcutta.

Site and Foundations: East Pakistan is very flat and low lying and most areas in the southern and central portions are subject to flooding. Surveys by the Pakistan Industrial Development Corporation indicated that an area near Khulna on the Bhairab River was the best available for those industries drawing their raw materials from the southern parts of the country. Construction of several jute mills and a shipyard had been either started or completed in this locality by 1954, and an area of 65 acres had been reserved for the projected newsprint mill.

Records of previous borings in this vicinity showed that the general area was built up of successive layers of silt, clay and sand to a depth of 1,000 ft. No rock or gravel strata have been discovered by the borings done to date. It was necessary, therefore, to carry out investigations of a specialized nature to determine the best type of foundations for the mill. Mr. Paul Cook of Vancouver, a specialist in foundation analysis, was commissioned to outline a plan of investigation that could be carried out by the engineers on site, to analyze the results, and to recommend the most economic type of foundation.

In accordance with Mr. Cook's instructions, two series of test holes were drilled. Analyses showed that the only layer that might be considered compressible was too deep to be affected by the loads imposed by the mill and that the sub-soil structures were sufficiently uniform to allow complete freedom in locating the buildings on the site.

Soil bearing tests determined that the maximum allowable load for spread footings was 1,200 p.s.f. Therefore, spread footings could not be used to support the heavier loads of the main mill buildings without excessive settlement, but would be suitable for the lighter structures where a small amount of settlement could be tolerated.

It appeared that heavier loads would have to be supported on piles. Precast concrete piles were considered to be most satisfactory, and test piles were cast. These were driven into a layer of relatively coarse sand which lay at a depth of about 20 ft. Calculations based on the driving test predicted that piles 25 to 30 ft. long would support loads of 50 tons without undue settlement. Loading tests on these piles, however, showed that safe loading was nearer 30 than 50 tons per pile. Footing designs were consequently based on the 30 ton figure, and the number of piles increased from 1,200 to 1,700.

Water: Perhaps more than any other industry, the manufacture of pulp and paper requires a large amount of relatively pure water. The obvious source was the Bhairab River. However, since the Bhairab River water was heavily laden with silt and suspected of being contaminated with sea water, it was considered necessary to embark on a program of testing and to investigate alternative sources. As the only alternative appeared to be wells, test wells were drilled and samples were taken from the wells and from the river. The results of these tests showed that the river water contained much less of the harmful chemical components than did the well water. Further, these tests showed that the only treatment required of the river water was the removal of the suspended material — a relatively simple matter.

As various patented treatment systems were found to be unnecessarily complex and costly, a simplified system using standard equipment was adopted at the suggestion of the water consultant. The treatment plant reduces the suspended matter to 6-10 parts per million which is sufficiently clear for newsprint and mechanical printing papers.

Capacity: From studies of the amount of raw material available and the predicted demands for newsprint and printing papers in Pakistan, the capacity of the mill was set at 35,000 tons per year of which 23,000 would be newsprint and 12,000 printings.

Economics: Even though there were raw materials, process, markets, site and transportation, the venture had to be analyzed to determine whether or not it would be profitable. To this end, preliminary designs were prepared in sufficient detail to estimate the capital and operating costs. The selling price for the products on world markets was well known, and the annual earnings were estimated from them and from the operating costs.

Stated briefly, the estimates placed the capital costs at $20 million and the annual return before depreciation and taxes at about 20%.

Authorization: Our report on the feasibility and economics of the Khulna Newsprint Project was presented to the P.I.D.C. in December, 1954. In July, 1955, the venture was given government approval and we were instructed to proceed with the detailed engineering. Preliminary designs and equipment selection were nearly complete when word was received that the project had to be temporarily postponed. Work was resumed in April of 1956 and the last detail drawings were issued from Vancouver in July, 1958.

Finance: The project was financed by the P.I.D.C. with government funds, although toward the end of the construction program some financial assistance was received from the United States through their International Co-operation Administration for the purchase of some equipment, spare parts and operating supplies.

There were periods when the foreign currencies needed by the project were diverted to other needs. This was particularly so in the fall of 1958 when the army expelled the president, took over the running of the government, and saved the country from going bankrupt. The first action of the new regime was to freeze the expenditure of foreign currencies — a freeze that was in effect for about four months during which the supply of materials to the project was suspended.

Payment for the various phases of the work was by irrevocable letters of credit deposited at the banks named by the suppliers of equipment and services.

Construction

Materials: Materials for building construction in East Pakistan were generally more costly than in other parts of the world. In addition, quality tended to be unsatisfactory. Special measures often had to be taken to develop a supply and to check the quality of the material when received. Keeping the project supplied with materials required constant vigilance. Frequently, the project was kept in motion only by borrowing or trading materials with other projects in the area.

Concrete: Cement, although manufactured in West Pakistan, could not be landed at site for less than double the factory price. Nevertheless, this price was far less than would have been paid for imported cement, and justified the trouble taken to keep the project supplied. It was fortunately of satisfactory quality.

Coarse aggregate was not available in the area and local sand was not acceptable for concrete on the basis of sieve analysis. It was, therefore, necessary to freight these materials by country boat through a tortuous river channel system roughly 400 miles from a source of supply in the northern provinces of Sylhet and Chattak or, alternatively, by rail from India over a similar distance.

Steel: Neither reinforcing steel nor structural steel shapes were available in Pakistan although a rolling mill in Chittagong did roll a portion of reinforcing requirements for the project from billet steel imported from Europe. Because the resulting reinforcing rods were not of uniform cross section, they were used only where stresses were low. Swedish reinforcing rod was employed in all highly stressed concrete, although much of this type of concrete construction was delayed by late deliveries of the material.

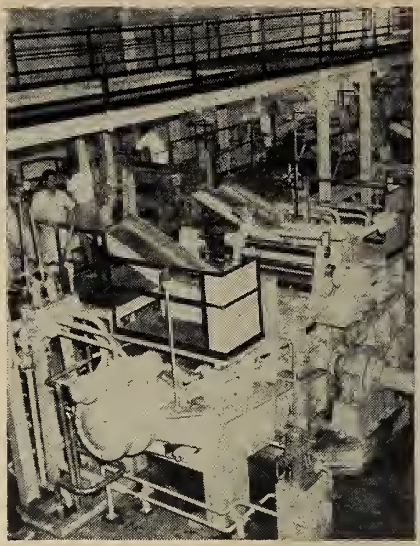


Fig. 3. General view of Grinder Plant showing Pakistanis operating the pulpwood grinders.

Roof trusses for mill buildings and structural steel framing for the Boiler House were fabricated and imported from North America. All structural steel shapes such as angles, channels, and beams for miscellaneous light framing were imported in bulk and fabricated on site.

Lumber: Lumber for formwork was so scarce that it was necessary to improvise a sawmill to cut form lumber from logs, and to use the lumber from packing cases for formwork. Most of the local sawmills were strictly hand operations which could not begin to meet the project demand for sawn lumber. The most popular woods for formwork were Keora from the Sundarbans Forest, and Gurjun from the Chittagong area. Both of these are dense hardwoods difficult to work, and susceptible to warping and checking. Where appearance was a factor, forms were lined with imported hardboard to avoid an unsightly finish resulting from shrinkage cracks and warping of form lumber. Fabrication and erection of concrete formwork was further handicapped by the fact that lumber was only available in short lengths, generally 6 to 8 ft, and numerous splices were necessary. In spite of the difficulty experienced in salvaging and redressing form lumber, every possible means was used to ensure a maximum re-use factor compatible with the construction schedule, and an average usage factor of approximately 1.5 was in fact achieved for the entire project.

Site Work: Work performed on site which would be considered unusual in North America included cutting and bending of all reinforcing steel, fabrication of miscellaneous steel platforms, brackets and handrail, fabrication of all pipe hangers and supports other than special spring hangers, fabrication of numerous items of handling and rigging equipment and, of course, performing the sawmill function in addition to normal wood framing yard work.

Labour: Manual labour was used almost exclusively for earth moving and for a major part of all materials handling where this was physically practical. Cost checks indicated that such methods were as cheap as mechanical handling and released equipment for tasks which could not be handled manually. An efficient dry-batch concrete plant and three 3½ cu. yd. motor truck mixers permitted an average weekly concrete pour of about 500 cu. yd. throughout the main concrete pouring schedule. Sufficient modern construction equipment was available to permit most elevated concrete pours to be made by conventional crane bucket or skip hoist and concrete buggy. From time to time a human chain, conveying concrete in metal head pans, was organized for certain types of pour where a good deal of framing to prepare for concrete buggies would otherwise have been necessary. Many of the columns were poured in this manner.

Equipment Installation: Equipment installation commenced in September, 1958, with erection of No. 1 Boiler, and No. 1 Paper Machine and was completed by July, 1959. Effective erection time for each boiler was approximately 5 months and for each paper machine 7 months. Mechanical tradesmen available locally were sufficiently skilled for most equipment installations if carefully supervised by European foremen and Vendors' representatives. Vendors' erection engineers supervised Pakistani erection crews directly in erection of the boilers, installation of process instruments, application of tank lining and in fact wherever there were special erection problems.

Piping: A start on piping work was made in September, 1958, when a small initial order of pipe and fittings arrived on site. Prefabrication work with these stocks commenced immediately and no doubt provided a useful training period for Pakistani tradesmen. Piping work could not proceed at the desired rate, however, until the main orders of pipe and fittings arrived during the latter part of October. Pipe fitting progress was greatly hampered throughout the programme by shortages of materials and many temporary substitutions had to be made to keep the job rolling. Valve substitutions were quite common and where this was not possible, piping was erected with spacers to maintain gaps equal to face-to-face dimensions of the missing valves. Because of a shortage of ready-trained tradesmen, pipefitting workmanship was, generally speaking, of lower quality than that of other trades, but was nevertheless satisfactory for the project.

Electrical Work: Electrical work was carried out by the contractor with a small supervisory force directing a larger crew of Pakistani tradesmen at times augmented by working foremen provided by the suppliers of electrical equipment. The Pakistani personnel were not particularly well trained when they arrived on the job, but as a result of intensive on-the-job training, the work went very well. Owing to late delivery, installation of electrical equipment and lighting did not commence until mid-October, 1958. Electrical crews reached a peak of about 240 Pakistanis and 12 Europeans in March to April, 1959.

Mill Services: The water supply and distribution system was the first of the mill services to be completed. This service was required, of course, before either steam or site-generated power could be produced to permit checking out of equipment and start-up of the mill. The water treatment plant was placed in operation in early April and, through the temporary installation of a stock pump in the system, provided the initial water supplies for flushing and testing mill process equipment. Early in May the proper water pumps arrived and the permanent water distribution system was placed in operation.

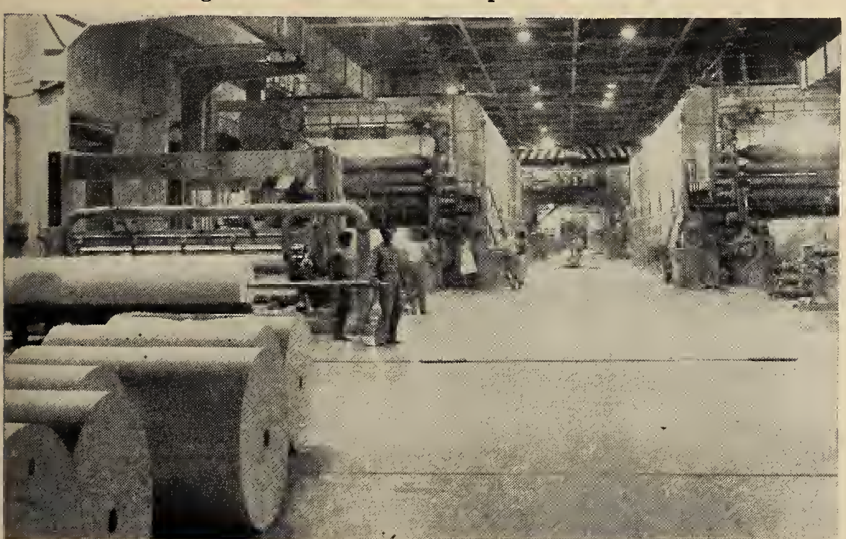
Following completion of the permanent water supply to the Boiler House and testing of boiler feed-water treatment equipment, the first boiler was fired on May 10 and the first electricity was generated on site on May 22, 1959. Electricity for construction power, colony service and equipment testing was produced on site continuously from this date.

Procurement: Each important item of equipment was selected only after competitive bids had been received.

It was then necessary to get permission in the form of an import licence to pay for the equipment with foreign exchange, and to get an irrevocable letter of credit deposited in the Vendor's bank. The purpose of the import licence was to control the expenditure of foreign exchange, and these licences were, by necessity, rationed. It is not surprising therefore that import licences often took months to secure. Nor is it surprising that the expiration date of licences was often approached before letters of credit were established, or that licences expired before goods were manufactured and shipped.

That the inevitable delays inherent in such a necessarily restrictive program were kept to a minimum is a tribute to the officials of the Pakistan Government and of the Pakistan Industrial Development Corporation as well as to the engineer, contractors and suppliers.

Fig. 4. General view of the Paper Machine Room.



Project Completion

Construction Schedule: The construction schedule for the Khulna Newsprint project as initially conceived in 1955 required site clearing to commence in November, 1956, mill construction in March, 1957, and equipment installation in December, 1957, to meet a scheduled start-up in May, 1959.

Owing to initial delays in implementing the construction programme, site clearing did not commence until December, 1956, mill construction until September, 1957, and equipment installation until September, 1958, nine months behind schedule. In spite of this and the delays in allocation of import licences, the first paper was manufactured on Paper Machine No. 1 on June 30, 1959, basically on schedule.

Equipment Testing: As mechanical and electrical installation work neared completion, a plan for testing the equipment was evolved. Check lists were prepared, itemizing faulty or incomplete work in each of the major mill systems. A segment of the contractor's work force was then allocated to correct all listed defects in logical sequence, so that each piece of equipment within a system was ready for testing in the proper order. After re-checking, the equipment was tested.

Operating Personnel: Because trained personnel to operate the paper mill were not available in Pakistan, the P.I.D.C. appointed us Mill Management Consultants for the Khulna Project in 1957 with the responsibility of hiring and training the necessary European and Pakistani personnel to start up the mill and operate it for approximately 18 months. As part of the training program, several key Pakistani personnel were sent to North America for training courses at various operating mills. Key personnel were brought to the site 8 or 9 months before the scheduled start-up date, so that they would have time in which to become thoroughly familiar with the mill, and to ensure that they would have arranged for an ample supply of spare parts and operating materials. In addition, key operating personnel cooperated in the final checking out and testing of mill equipment.

All other personnel were engaged in East Pakistan by more or less normal hiring procedures modified to conform with local custom. Key operating personnel were of great assistance in scrutinizing the hundreds of applications received. It is perhaps interesting to note that the work force eventually hired for the mill was drawn almost exclusively from the literate component of the population.

Between 40 and 50 key people, mostly from the United Kingdom and Canada, are at present employed at the mill supervising the operation of equipment and carrying out the training of approximately 850 Pakistanis who make up the working force.

Start-up: The start-up of the mill, though not entirely without incident, was surprisingly trouble-free, and the success of this phase of the project may be attributed at least in part to the comprehensive testing and checking procedures.

Perhaps the most serious trouble during start-up resulted from undersizing the motors on the fresh water pumps. One motor burned out and it appeared that the other two would follow. To prevent this from happening, one of the 4 impellers on each of the 2 remaining pumps was removed, thus reducing the load to within the limits of the motor. As a result, design heads and capacities were not reached. However, since the water demand had not built up to its peak, we were able to limp along until larger motors could be delivered. These motors have since been installed and, with the impellers replaced, the pumps are functioning well.

Another trouble spot occurred in the speed reduction unit coupled to the induced draft fan on No. 2 Boiler. Excessive vibration and heating caused us to examine the individual gears and one of them was found to be imperfect. To correct the imperfection was beyond the scope of the shop facilities in the country and we were forced to wait about 6 weeks until a spare arrived from the United Kingdom. Once again we were able to get by on one boiler during the first weeks of operation when the steam and power demands were below normal.

The first paper was produced on Paper Machine No. 1 on June 30, 1959, and on Paper Machine No. 2 on July 31, 1959. For initial runs, the furnish consisted of a mixture of imported chemical pulp and Gewa groundwood pulp. The percentage of long fibered chemical pulp was kept large in order to provide a strong sheet and minimize breakages. After the machine had been thoroughly tested on this rich mixture, the content of chemical pulp was reduced to about 20%, and, with the addition of chemi-ground pulp, reduced still further to about 7% — well within design figures.

Both machines are operating at about 70% of their design speeds and little trouble is anticipated in reaching or even exceeding design speeds when market conditions dictate.

The quality of the newsprint and printing papers so far produced at the Khulna mill is good and the forecast is that there will be little difficulty in selling the capacity output of the mill.

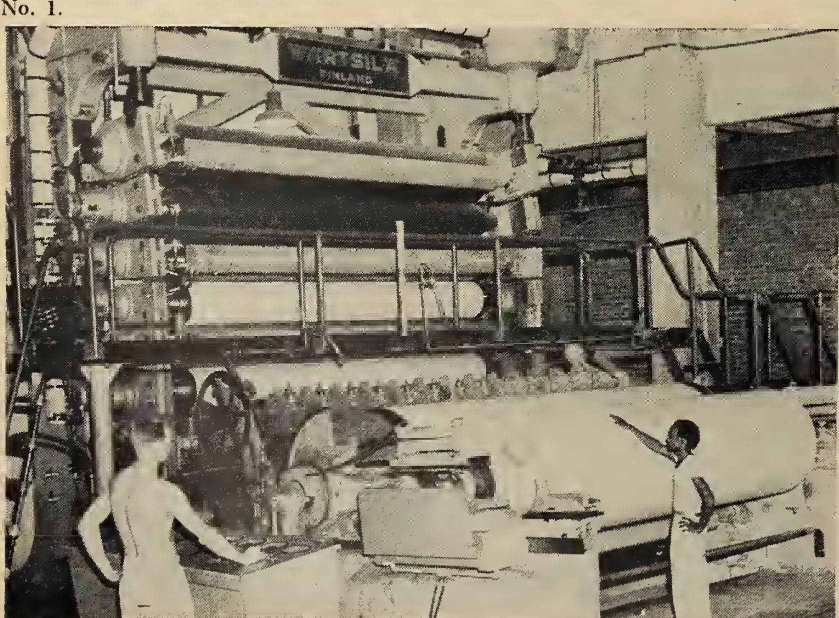
Conclusion

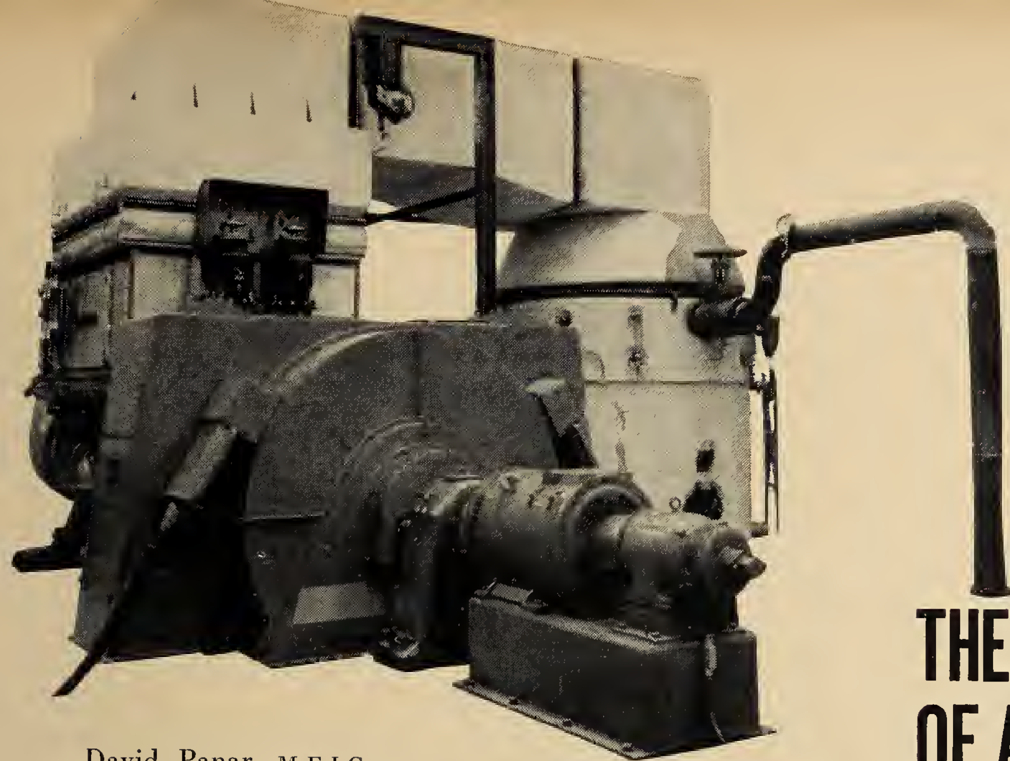
Canadian Engineers can be proud of the Khulna Newsprint Project because it is believed to be the first newsprint project in which they have been concerned with every phase from start to finish.

There are other reasons for being pleased with the results. The preliminary engineering work carried out for the purpose of determining economic feasibility turned out to be sound. Detailed engineering failed to reveal a single important instance in which final design principles departed from those envisaged in the preliminary stages. Perhaps the most significant change was in the layout of the mill buildings on the site, which in the final arrangement was at 90° to that of the preliminary plan.

Despite a six month delay in the start of the construction program and a four month freeze on foreign exchange during the program, the job was finished essentially on schedule.

Fig. 5. Pakistani trainee and European supervisor tend the reel of Paper Machine No. 1.





THE ECONOMICS OF AN INDUSTRIAL GAS TURBINE

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

The use of large size gas turbines for peaking power is not a new application for electrical utilities. The Port Mann Station[1] of the B.C. Electric Company and the City of Edmonton Power Plant are two notable examples in Western Canada. The gas turbine in the smaller sizes (5,000 kw. and less) has been mainly used for process work such as oil field pressuration and natural gas transmission line pumping. Smaller sizes have also been used as base power plants at isolated independent plants such as Fort Stockton Texas[2]. The use of the small size gas turbine as a source of peak electrical power in conjunction with purchased and steam generated power in the industrial installation has not been too common. At the University of Alberta we have, we believe, Canada's first such use of an industrial gas turbine. It will be the subject of this paper to briefly discuss the economics involved and to describe the installation.

TYPICAL daily load curves of the needs of the University of Alberta are indicated in Fig. 1. It will be noticed that the summer and winter curves exhibit similar trends and it can be seen that the load factor, typical for an industrial installation, is quite poor. This is caused primarily because the University is an eight hour a day institution. While there are the occasional evening classes and night laboratories, the bulk of the work is done during the normal working day. This rather poor load factor is reflected in the electrical charges which are made by the City of Edmonton for power supply to the institution. Appendix 1 is a copy of the City of Edmonton rates and the rather severe penalty for high demand is indicated in the rate structure. The demand meter is reset once a year so that the worst condition which occurs demand wise is reflected in the payment for the entire twelve months. Justification for this charge by the City of Edmonton can be seen if we briefly review the actual costs of producing power.

Power Costs

Many[3] authorities divide the cost of electrical power into three main elements. The fixed element, the energy element and the customer element. The fixed element includes the capital cost of the plant distribution system as well as the depreciation and taxation which these are subjected to. This is usually expressed as a percentage of the total cost of the plant and the total cost of the plant in turn is influenced by the maximum power which it must produce; the charges of depreciation, taxation, management and other fixed elements of cost do not vary as the load is reduced. The energy element which will include fuel costs, labor costs, supplies and maintenance are influenced by the actual energy produced but in turn also these have a fixed element. The cost of supplies and maintenance of a turbine running lightly loaded are very close to those of the same turbine running under a normal or even heavy load. The customer element of cost which includes the distribution system, transformers, meters and so forth is again influenced by the maximum demand which the customer uses even though it may be for a very short time.

It therefore seems reasonable if a customer is attempting to reduce the electrical energy charge that the first approach should be made at reducing the demand and the demand charges. Of course, if some electricity can be produced as a by-product during a process, less electricity need be purchased and electrical utility charges will be reduced. This approach is quite common in a number of industries which require process steam and it is felt that the details of this technique have been efficiently covered in other literature[4] to require no more than a brief résumé.

By-Product Power

Many industrial plants require steam for their processes and/or heating purposes. If the steam is required at a pressure below that which can be readily produced, an industrial steam power plant is operated at a pressure somewhat higher than the process requirement so that a steam turbine or engine may be used as a reducing valve and in turn electrical energy is produced. Since the added thermal energy required to produce the higher pressure steam is usually quite small, electricity produced in this manner is very economical. Unfortunately the production of electrical energy in this manner, in many cases, is more simple than the accountants determination of the cost. It is this writer's opinion that since electricity is essentially a by-product, the costs which be attributed to it are those which can be actually charged to it; namely, the additional costs for boilers to produce the higher pressure steam, the additional cost for fuel to produce the higher enthalpy, the wages of the engineers necessary for the steam power plant but not those for the steam heating plant (unless a higher certificate is necessary—and then only the difference should be charged). In many cases, these costs are difficult to determine and approximations are used in order to apply interplant accounting procedures. At the University of Alberta, the electricity is charged to the various departments and buildings at the City utility rate and the cost of heating steam is reduced so that the power plant operation is basically nonprofit. The rationalization here, while there may be an overcharge for electrical energy, there is a corresponding undercharge for the steam and therefore the total cost of each department will be equalized.

This technique, however, does not overcome the high demand costs because unfortunately, the production of electrical energy is dependent by the use of the process steam, and if this steam is used basically for heating, a considerable energy charge can occur during the nonheating periods of operation. There are also periods, during extremely cold weather, where additional steam is needed beyond what can be passed through the turbines, and this represents an additional cost since the steam no longer has a by-product credit and the full cost of steam generation must be applied.

Gas Turbine Power

The industrial gas turbine seems to supplement the steam turbine in the above regard. We have a machine which produces electricity as its main product and steam as the by-product. Electricity can be produced at all times of the year and when the by-product steam is needed, it can be produced with very little additional cost. The type of gas turbine and its arrangement will determine the ratio of fuel costs to electricity and steam produced. While the large number of combinations which are available in the larger sizes have not yet been used in the smaller gas turbines, there are several distinct choices which can be made. (See Fig. 2).

Single Shaft

The single shaft compressor—turbine—alternator with possibly reduction gear between the turbine and the alternator, is perhaps the simplest to construct and operate. There is one operating speed, namely the synchronous speed of the alternator. This has a rather sharp efficiency curve and is best suited for design load.

Series Shaft Machine

The usual arrangement of this type is that the gas compressor and its turbine (called the charging set) are mounted on one shaft and the power turbine which is connected to the alternator is on a second shaft in line with, but not connected to, the charging set. This allows the charging set to vary in speed while the power turbine and its geared alternator operate at the synchronous speed. Efficiencies are somewhat higher over the usual operating range and the starting motor does not have the added load of rotating a fairly large alternator.

The Two Shaft Machine

This type is more commonly employed in larger machines where there are two stages of compression and expansion. This allows intercooling between the first and second stage of compression and also allows reheat between the high pressure and the low pressure turbine. We now have basically two gas turbines, two compressors, one low pressure and one high pressure. This also has two combustion chambers, one high pressure and one low.

All of the above can be equipped with regenerators which allow the exhaust heat to preheat the compressed mixture before it enters the combustion chamber and/or waste heat boilers which allow the exhaust gases to supply process steam. The turbine at the University of Alberta is of the second classification, equipped with both a regenerator and a waste heat boiler. The regenerator, in preheating the compressed gases, increases the thermal efficiency a significant percentage (16 to 23%) and yet the exhaust gas temperature is still sufficiently high to produce heating steam. Let us examine more closely the University of Alberta installation.

Gas Turbine Power Plant

The design of a gas turbine power plant does not differ materially from any other type of power plant. It has the problem of supplying the raw materials, eliminating or transferring the waste products and transmission of the power produced. There is one rather significant additional problem with gas turbines of the open cycle type. Due to the fact that the working substance is air in rather large quantities, almost 15 cu. ft. per min. for each horsepower produced, and that this same weight of air (with some additional burnt fuel) must also be exhausted to the atmosphere and in many cases at quite a high temperature, we find that a new parameter has been in-

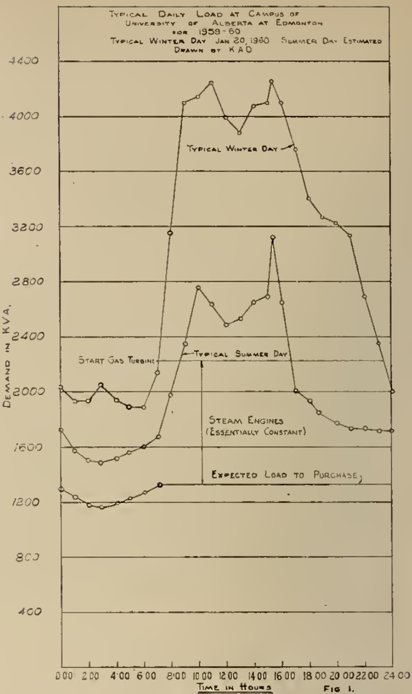


Fig. 1. Typical Daily Load Chart.

troduced into design consideration, namely, that of sound. The gas turbine at the University of Alberta area has been installed in a residential-hospital-teaching zone which has made the sound problem one of paramount importance. The gas turbine heat exchanger duct work, and waste heat boiler have been placed towards one end of the power plant and the wall behind the turbine houses the air intake duct. The north side was selected for the air intake in order to obtain the coolest air possible and this orientation allows the longest clear distance before any buildings or reflecting surfaces are encountered. In order to keep duct lengths as short as possible, the exhaust stack is also on the north side. Fig. 3 is a view of the intake silencers from the downstream side and shows the rather successful straight line flow type of silencer which has absorbent vertical members that absorb the sound energy with minimum pressure drop. The air intake filters are shown in Fig. 4. It might be added that no special silencing treatment was carried out on the exhaust since it was felt that sufficient attenuation would occur as the exhaust gases passed through the heat exchanger and the waste heat boiler. While one of the theoretical advantages of the gas turbine is that no cooling water is needed, in practice some cooling is necessary to remove the heat from the lubricating oil of the gas turbine. This oil in turn has cooled the gas turbine bearings and removed some of the heat which has been transmitted to the bearings by the high temperature blading and discs fastened to the shaft. Cooling water was also necessary for the gas compressor and the generator. In order to make this power plant as self sufficient as possible and to keep the water charges at a minimum, a cooling tower has been also installed in this installation. Year round operation of the plant being mandatory, the cooling tower was installed indoors. This is a standard outdoor type of cooling tower which has been selected oversize and installed in an upper corner room of the power plant building. Louvers are installed in the two walls as well as the roof and these are automatically operated as the temperature of the cooling water increases. All louvers are metal and while severe frosting has been encountered on the roof or upper louvers, these are of the locomotive type with very powerful actuators which can be opened even though they are heavily covered with frost. Once the roof louvers are opened, natural draft through the wall louvers tends to remove the frosting formed and these are opened by normally sized motors. Unfortunately, we have been unable to test the cooling tower under summer conditions and therefore the actual reduction in capacity due to this indoor installation cannot be given.

Special Instrumentation

While the power plant is south of the actual campus, extensive instrumentation has been provided by the manufacturer for student testing. This includes a 24 manometer panel with mercury or colored water as the indicator fluid allowing students to determine the pressures of the operating gas turbines at the various significant points. A sixteen point temperature recorder is also included with the student instrumentation and this automatically indicates and records the temperatures at the significant points. Further instrumentation such as gas flow, steam output, intake temperatures, are installed around the walls in the area of the gas turbine.

This rather complete instrumentation has allowed senior and graduate students of the University of Alberta, to observe an industrial gas turbine under actual operating conditions. The proximity of this power plant to the University and its instrumentation will allow a most interesting and informative group of tests to be conducted by the students. To the best of this author's knowledge this installation is the world's first for students in a regular mechanical engineering degree pattern. Perhaps one should now look at the economic factors.

Economic Feasibility

In the economic justification of a gas turbine installation one must consider possible savings against probable costs. The yearly electrical charge for the university area if all power were purchased would be \$231,000. This is for 20.1 $\times 10^6$ kwh. at a load factor of 0.55 and a power factor of 0.80, resulting in a kilowatt-hour charge of 1.15 cents. The present steam generating plant (assumed to operate at 100% utilization factor for 6 months of the year) can produce 3.33 $\times 10^6$ kwh. per year. The gas turbine used as a peak load generator can produce 5.27 $\times 10^6$ kwh., which means that the City of Edmonton will then supply 11.4 $\times 10^6$ at a load factor of 0.98. This power will cost 1.01 cents per kwh. (compared to 1.15) and the steam produced power should be evaluated at 1.01 (it can be produced for much less, but this is to the credit of the steam plant—not the gas turbine) and the break-even summary of costs will be as follows.

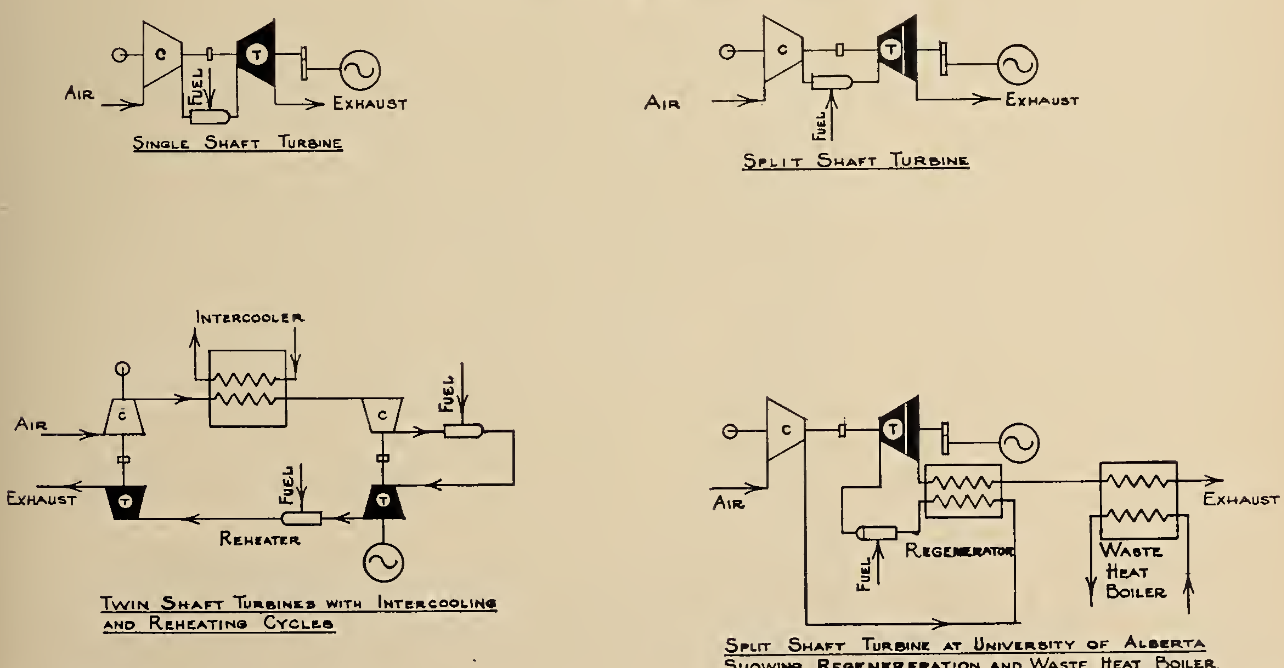
Purchasing all Electrical Energy

20.0 $\times 10^6$ kwh. at 1.15c (load factor 0.55), annual electrical charge		\$230,000

Gas Turbine, Steam Engine plus Purchased Electrical Energy

Purchased, 11.4 $\times 10^6$ kwh. at 1.01c (load factor 0.98)	\$115,200	
Steam Engine Production, 3.33 $\times 10^6$ kwh. at 1.01c	33,700	
Gas Turbine Production, 5.27 $\times 10^6$ kwh. at 1.54c	81,100	
		\$230,000

Fig. 2. Open cycle gas turbine variations.



In other words the gas turbine should be able to produce its power for less than 1.54 cents per kwh. before it becomes economically feasible.

Gas Turbine Costs

The gas turbine purchased by the Government of the Province of Alberta procured on a combination purchase-gift was evaluated at $300,000. It has a guaranteed output of 1980 kw. at 48°F, and supplied with a 2200 kw alternator to take advantage of greater power outputs at lower ambient temperature. The cost per kilowatt hour of capacity is very close to $150. In addition to the turbine there must be supplied a cooling tower, gas compressor, intake silencers, and electrical switch gear. These items are 10 per cent. or an additional $30,000. The building space occupied by the gas turbine and its auxiliaries is approximately 75,000 cu. ft. at $1.00 per cu. ft. or $75,000. Thus the total capital costs are approximately $405,000 or slightly more than $200 per kilowatt of capacity.

Operating Costs

Natural gas is the cheapest fuel available in the City of Edmonton, costing 2.3 cents per therm (100,000 B.t.u.) or 23 cents 10^6 B.t.u. Bunker "C" oil is approximately 40 cents per 10^6 B.t.u. Also there is no storage cost associated with natural gas and while there is a minimum demand charge of $100 per month, this is assumed to be borne by the steam plant.

No additional staff are to be employed for the gas turbine, and since it is to be operated in conjunction with two steam turbines, but only for 8 or 10 hours per day, it was felt that one-third the cost of two shifts should be charged to the gas turbine. With supervision, the hourly cost of shift engineers is $3.20 per hour.

There has not been sufficient running time to establish the cost of supplies, oil, minor repairs, etc., but it is anticipated that this will be fairly small, somewhat comparable to a steam turbine, oil consumption being negligible, $300 per month is the value used. There may be the repair of a larger nature or other unpredictable, and therefore a contingency sum of $1,000 per year is also provided.

Depreciation Allowances

It is estimated that the gas turbine and its auxiliaries, will have a life of 20 yr. (reblading is recommended by the manufacturer at 40,000 hr.) and the building will have a life of 40 yr. The depreciation values are therefore 5% and 2½%.

Total Operating Costs

The yearly operating costs with an average thermal efficiency of 20% may be summarized as follows.

			Mills per kilowatt-hour
Fuel	$\frac{5.27 \times 10^6 \times 341.3}{0.20 \times 100,000} \times 2.3$	$20,700	3.96
Labour	$\frac{16 \times 365 \times 3.20}{3}$	6,230	1.18
Supplies	300 × 12	3,600	.87
Contingency		1,000	
Depreciation	Gas turbine, and auxiliaries, 5% of $330,000	16,500	
	Building, 2½% of $75,000	1,870	3.46
	Total	$49,900	9.47

Return on Capital

It was noted previously that the power could be purchased for $81,100, therefore the saving, using the gas turbine, is $31,200. With a total investment of $405,000, this represents a return of

$$\frac{\$31,200}{\$405,000} \text{ of } 7.7\%$$

Waste Heat Boiler

If the value of the steam produced by the waste heat boiler is credited to the gas turbine a greater return is shown. The minimum steam consumption at the university area is over 10,000 lb. per hr., and therefore it is theoretically possible to produce steam at all time, however, the steam engines are of the back pressure type and in order to allow them to produce electricity, steam would only be produced by the waste heat boiler when the steam engines are at their maximum, namely the winter months. On this basis it is estimated steam will be required for 4 months. The waste heat boiler has a capacity of 10,000 lb. per hr., therefore the annual waste heat boiler production will be in the vicinity of 4 × 30 × 8 × 10,000 or nearly 10 million lb. of steam. The steam generating plant pay 2.3 cents per therm for natural gas and with an efficiency of 80% steam has a cost of 28.8 cents per 1,000 lb. The waste heat boiler therefore will save an additional

$$28.8 \times \frac{10,000,000}{1,000} = \$2880$$

The rate of return is now

$$\frac{\$3,1200 + \$2880}{\$405,000} = 8.45\%$$

If the waste heat saving is credited to the gas turbine generation costs, the cost per kwh. is

$$\frac{\$49,900 - \$2,880}{5.27 \times 10^6} = 0.895 \text{ cents.}$$

If money is borrowed at 6%, and this cost is added to the yearly production cost, we find the cost per kilowatt hour is

$$\frac{\$47,200 + \$24,300}{5.27 \times 10^6} = 1.35 \text{ cents,}$$

which is still below the "break even" charge of 1.54 cents per kwh. The charge of this borrowed money would be 4.56 mills per kwh., which represents the largest single item of electrical cost.

Other Economic Considerations

Naturally, if the hours of operation of the turbine are increased as load increases, greater savings are possible since the fixed charges at present make up the major share of the overall costs. There is also the possibility of operating the gas turbine (or perhaps a second one) as a base plant and purchase peak power from the City of Edmonton.

The use of the exhaust gas which still has a temperature of 310°F. after leaving the waste heat boiler as combustion air for the steam boiler plant has been considered. However, this will require considerable correlation between steam plant and gas turbine loads and operation. The design of the existing exhaust duct work is such, that should this interconnection prove feasible, it can easily be done.

One other possibility for considerable saving is due to the price structure of natural gas. Since this fuel is also used for steam production, the cost used in the calculations has been the normal commercial rate. In order to encourage high load factor of the installed gas transmission line, customers are offered an "optional" or high load factor rate which can be requested by industrial gas users whose summer consumption is at least forty percent of the yearly total. Thus, by operating the gas turbine for a greater period during the summer months, the annual gas costs may be reduced a significant amount. This phase will also be examined during the current summer's operation.

There is one other asset to this installation other than its economic and instructive possibilities. The university area power plant serves a hospital area, which includes University Hospital and its associated clinics as well as the Aberhart Memorial Sanatorium. The supply of continuous electrical power to hospitals is a problem most of us can readily appreciate, and while certain very strategic areas such as operating room lighting, poliomyelitis patients, iron lungs and other more dramatic areas, may be served by storage batteries or emergency diesel electric sets, it is very difficult to isolate any area in a hospital and say that continuous electrical energy is not necessary, and while the continuity of energy as supplied by the City of Edmonton has been very good, there has been and will be outages of some duration. The gas turbine can be started cold to full power in eight minutes and for this purpose a diesel electric plant is installed in power plant and this automatically comes on the line with the City of Edmonton voltage drops.

Commissioning of gas turbine has not been without the usual frustrations and delays. But the dependability and reliability of this source of power is now an established fact. The noise problem appears to be solved. There seems to be a large and growing need for the flexibility and diversity of the gas turbine.

It is felt that installation of the type described herein, with perhaps some modification will become more common as our needs for economic and supplementary power grow.

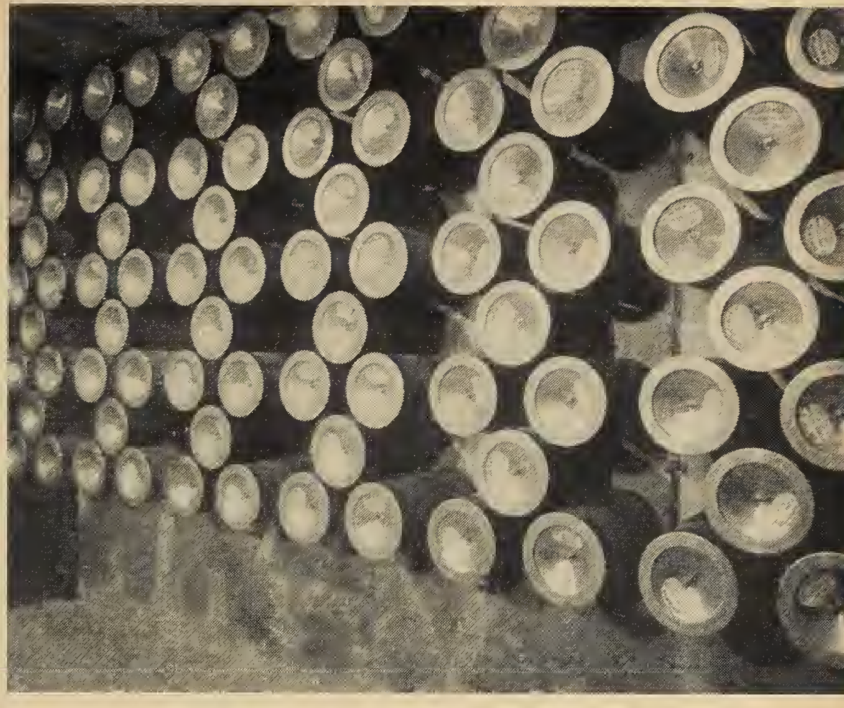


Fig. 4. Secondary air filters.

Fig. 3. Sound attenuator.

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APPENDIX No. 1

The City of Edmonton Electric Light and Power Distribution System

NETWORK POWER RATES 1956

Commercial Power—4,160 Volt Service, 75 kva. or over.

Customer supplying All Transformers, Switching Equipment, etc., Service to be taken at 2,300 Volt, balanced three phase and having a measured maximum demand of not less than 75 kva. taking a minimum consumption of 10,000 kwh. per month.

First 100 hours use of kva. of demand at 1.1c per kwh.

Next 100 hours use of kva of demand at 1.0c per kwh.

Next 200 hours use of kva. of demand at 0.09c per kwh.

Over 400 hours use of kva. of demand at 0.08c per kwh.

Plus a Service Charge of 50c per kva. of demand taken at the highest 15 minute interval in any one month, and this shall be accepted as the maximum demand for the succeeding twelve months, or until a greater demand is established.

Minimum Bill $145.00 per Month.

JOINTS IN PRECAST CONCRETE BUILDING FRAMES

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

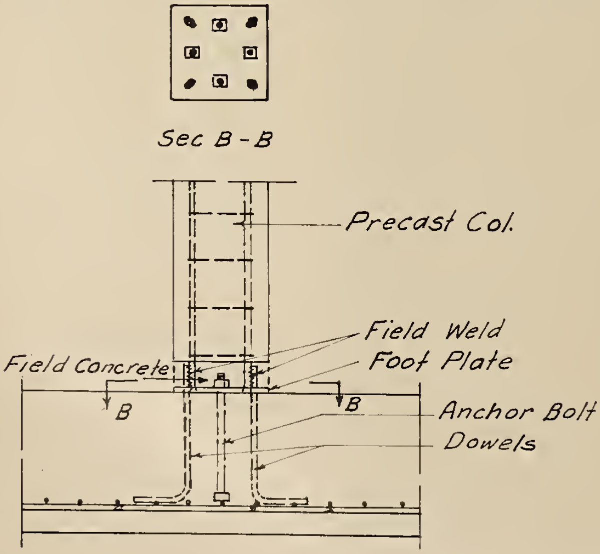
This paper discusses the technical and economical aspects of joining together precast reinforced concrete beams and the fixing of columns to their supports. Methods and details of jointing which have been worked out during the last 12 years by the writer are described. Basic principles in the development of suitable joints are discussed. The discussion also deals with jointing under winter conditions.

BOTH STRUCTURAL sufficiency and the economy of precast reinforced concrete building frames depend largely on methods of joining the individual members together. There is generally little or no saving of materials involved in precasting beams and columns and any saving obtainable must, therefore, be in connection with form work and labour. Precasting is for this reason justified only in cases where the combined cost of casting, transport, erection and joining is less than the cost of casting the members in place, or where saving of time is an important consideration.

Forming and casting a reinforced concrete member at the ground level can always be done more cheaply than up in the air where the member needs special support. This is the chief source of saving by precasting. From this saving must be deducted the cost of transport from the factory to the site if the members are factory made and the extra profit to the factory. In addition to this comes the cost of placing the precast members and the cost of joining them together. An engineer who is designing on the basis of economy must consider the different phases of all these aspects and find out which method of casting is most profitable. Consideration must, of course, also be given to structural sufficiency which is not always easy to obtain in precast frames. It should also be noted that methods of casting in place have been considerably improved during the last decade.

The most variable and difficult problem to solve economically is the jointing of precast members. It is nearly always possible to design a joint which is sufficiently strong if little regard is paid to cost, but to obtain the proper combination of simplicity, economy and strength is often an extremely difficult problem. There has not been much to learn from what has been practised in North America in that respect. In most cases, joints used here have been of a simple type providing little or no continuity and quite often no other anchorage than that provided by bond and friction. The writer has not been satisfied with such simple joints and has tried to work out details which would make a structural precast concrete frame comparable in continuity with a cast-in-place frame. European practice as described in literature on precasting has been studied in this connection. The most advanced methods seem to be those used in Russia and the countries under its sphere of influence. The details used there, however, would not generally be economical under North American conditions. The reason for this is that we

Fig. 1. Departure from the pocket type column connection



do not use so much mass production of similar elements as in Russia and, therefore, cannot employ special equipment and devices repeatedly to the same extent. An even more important difference is our relatively higher labour cost which makes it unprofitable to use labour absorbing methods even if some saving of material can be achieved. Some of the joints developed and described in the paper, however, will hardly require any extra material in spite of their simplicities. A general discussion of the suitability of precasting may be found in an earlier paper by the writer.[1]

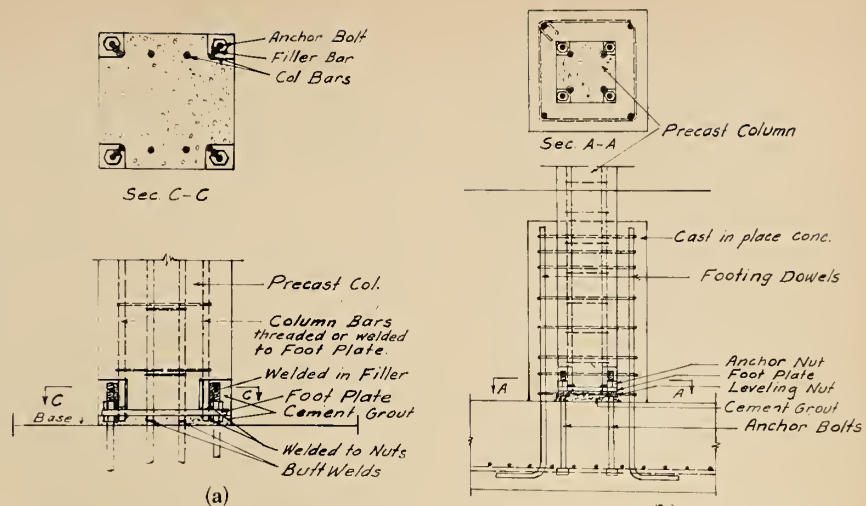


Fig. 2. (a) Screwed and welded joint. (b) Screwed and welded joint with collar reinforcement.

Column to Footing Connection

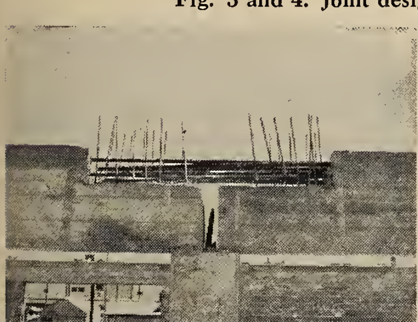
The providing of lateral stability in large industrial buildings or buildings of considerable length quite often constitutes a problem if no interior cross wall or bracing is feasible. In many cases the simplest solution is to fix the columns to their foundation so that these will resist the overturning moment from lateral loading. The bending stresses will under such circumstances often be much greater than the direct stresses from vertical column loads. About the simplest connection that can be used for obtaining bending moment resistance is to form a pocket hole in the foundation block into which the lower end of the column can be set. The hole is usually made about 2 in. larger on all sides than the column and should also be about 2 in. deeper than the lower end of the precast column. In practice, it is found to be almost impossible to finish off the bottom of a hole at correct elevation and level at the same time as the foundation block is cast. Before the columns are erected a pad smaller than the column cross section should be cast at the bottom of the hole and finished off at the correct level.

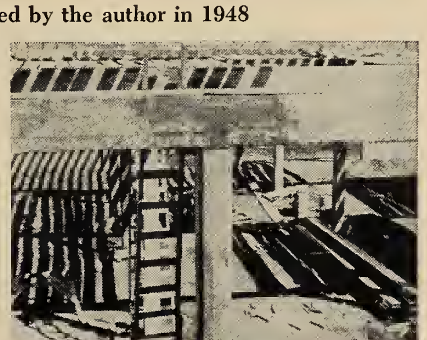
When the precast column is placed it must be held temporarily in place by means of wood wedges. Plumbing of columns can be made by adjusting these wedges. The space between the foundation block and the precast column is then filled with well packed cement mortar.

This type of column connection is very strong provided the pocket hole is sufficiently deep and the mortar packing has been well done. But it is a crude piece of work requiring much labour in forming, wedging, plumbing of column and packing of mortar. It is not cheap in material either and is not suitable if there is a basement under the floor where the footing is placed. This type of column base was copied from German practice and was used on our two first precast frame buildings before more suitable footing connections were developed.

The first departure from the pocket type column connection is shown on Fig. 1. and together with some later developments and improvements are covered by Canadian and U.S.A. patents. The idea with this connection was the cutting of labour cost, speed of erection, economy of material and unrestricted usability. There is no method which will allow a faster fixing of a column to its foundation than a screw connection. No temporary shoring is required and plumbing can be done at any time after erection so that the expensive erection work is done in the shortest possible time. It was found to be desirable and economical to get a direct connection between the anchor bars and the column bars. This would lessen the dependence on the bending strength of the foot plate so it could be cut down to a thickness just sufficient for erection. The most suitable way of obtaining a direct connection between upper and lower bars is by means of welding.

Fig. 3 and 4. Joint designed by the author in 1948





Apart from the work of welding there was some work required in packing the spaces left in the column with cement mortar. This work must, however, be done to a certain extent even with steel columns. An expanding agent put into the mortar is desirable. It is not likely that such a mortar joint will weaken the concrete section materially if it is well done and of uniform depth.

Plumbing is greatly facilitated by means of levelling nuts such as are sometimes used in steel construction. This feature has been included on all later designs. To cut work on mortar packing a special type of joint was developed where only small parts of the concrete corners above the foot plate were removed. This will constitute a weakening of the concrete section even when filled in later, because it is hardly possible to obtain the same strength as for a more homogeneous concrete section. The weakening in most cases will not be very important, however, if the column has a reasonably large cross section (Fig. 2(a)). The vertical steel bars can take considerable load without help from the concrete. Concreting may, therefore, be postponed and this makes the joint suitable for winter construction.

An alternative without direct connection between lower and upper bars, not a patented design, requires a thicker foot plate and the concrete section is weakened to an even greater extent than is the case where only the concrete corners are removed. The column section would undoubtedly be stronger if the remaining part of the concrete section were removed and later replaced with expanding cement mortar. We have not used this type of connection.

It might look as if the most advantageous design would be to use a larger foot plate than the column section so that the anchor bolts could be placed outside the column because no concrete would then need to be removed. The use of such a large plate is, of course, possible, but is inconvenient to include in the casting of a column. This is most often done on a platform and it is inconvenient to have any projection attached to a member which will necessitate the cutting of recesses in the casting platform. The cheapest method of casting is to use members of such a form that every second piece is first formed and cast. The forms are then removed, a bond breaking agent is put on the side surfaces and the sides of the first cast members are used as forms for similar members cast in between the first ones. It is, of course, possible to fasten a steel foot plate to the column bars after casting but this is not convenient and the foot plate needs to be extra strong. Any projection from a precast member which cannot be placed upwards during casting will increase the forming cost.

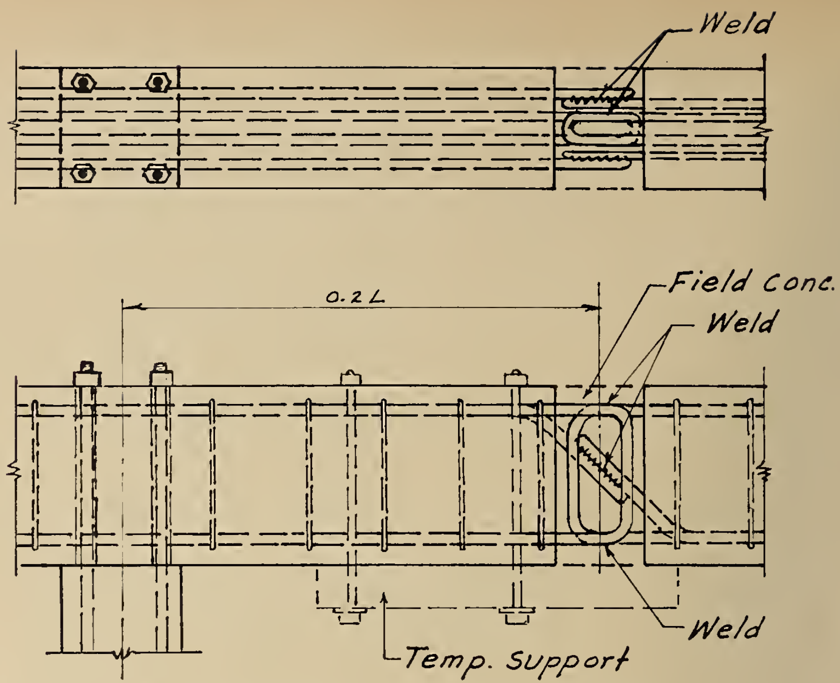


Fig. 5. Joint requiring temporary support until both horizontal bars and the diagonal shear bars have been welded together

Fig. 6. Structure with joints of the type described in Fig. 5.

In the case where the column is very high and has to resist considerable lateral loads from wind and crane impact, the writer has been reluctant to depend on the sufficiency of a welded and screwed connection. In a recent industrial building the lateral loading became quite great. A combination connection was, therefore, developed (Fig. 2(b)) where the usual screw connection would provide all advantages of initial fixing. A form for a concrete enclosing box was then placed around the column and filled with concrete. This concrete box is heavily reinforced with dowels projecting from the footing and with strong ties. The labour involved is much less than for the hollow foundation type, but the same strength as with this can easily be obtained.

Joints in Precast Beams

When our first precast frame was designed in 1948 the problem of joining precast beams had to be solved. The writer wanted to obtain continuity, but this was not economically feasible by such types of joints as were found described in European literature. A joint as shown on Figs. 3 and 4 was, therefore, designed and at the time was thought to be an innovation. Some years later, it was found that similar joints had been developed and tested in Russia. Tests there showed that lap splicing of the reinforcing bars at point of maximum negative bending moment did not cause lower ultimate strength than for a comparable case with fully continuous bars.[2] The reason for this is undoubtedly that at the section of maximum bending moment the amount of steel due to lapping is really doubled and that at the end of the laps where the amount of steel corresponds to the full bending moment, the actual bending moment has decreased considerably. These test results constitute an exception to the rule that reinforcement should not be spliced at points of maximum stress. It is, of course, not certain that tests would show the same result for shorter laps as might be employed with deformed bars.

We have used this type of joint in a large number of cases and never experienced any difficulties. The joint has the advantage that beam lengths correspond approximately to the distances between columns. No temporary supports are required for the beams which can be hoisted up and placed directly on the columns. As disadvantages might be mentioned, the considerable amount of labour required to bend the stirrup ends down and the proper packing of the joint concrete. The joint is not very suitable for a second story design and not really adaptable to winter construction.

A joint which requires considerably less labour is shown on Figs. 5 and 6. The joint can most conveniently be placed near the point of inflection. It requires a temporary support until both the horizontal bars and the diagonal shear bars have been welded together. The complete maximum shear should, of course, be taken by the diagonal bars. The centre suspended beam is stable after welding without any temporary support, but should not be subjected to heavy torsion before the joint is concreted. Filling the space between the beam ends with concrete is easily done and the finished joint is then hardly noticeable (see Fig. 6). The concreting might even be postponed until heating of the building has started and the joint may, therefore, be used for winter construction. We have used this joint in several cases with complete success.

A beam joint based on somewhat similar ideas is shown on Fig. 7. This joint will not require any temporary support and can be filled in with concrete at any convenient time. Labour involved is quite small and the joint is very suitable for winter construction.

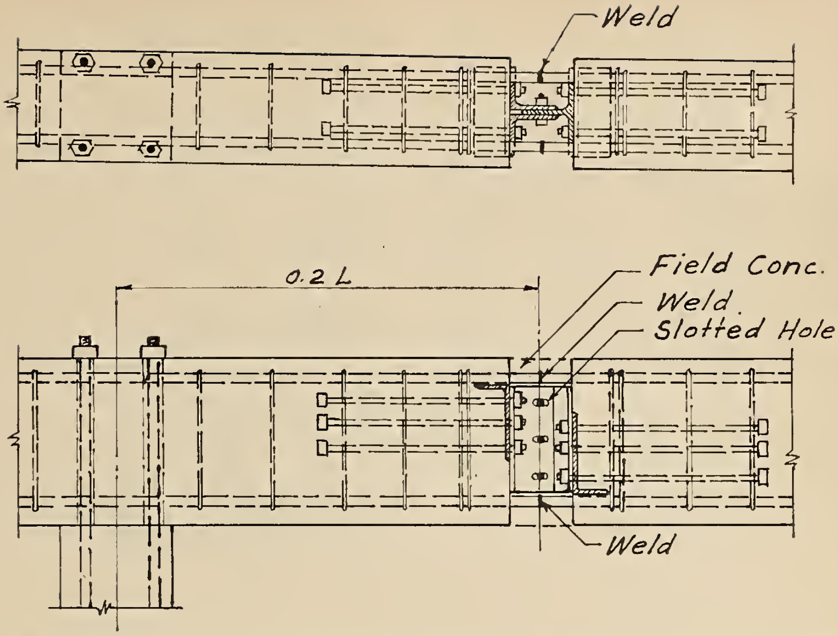


Fig. 7. Joint which does not require any temporary support and can be filled with concrete at any convenient time.

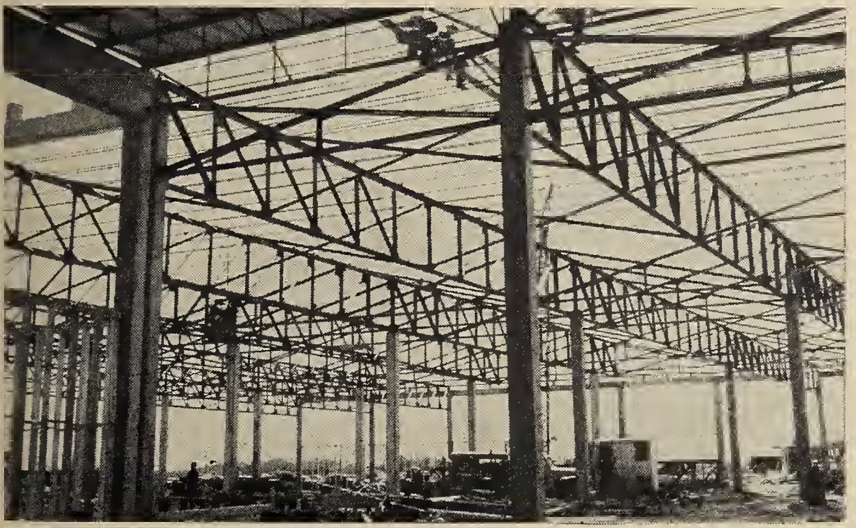
Joints Between Steel Sections and Concrete Members

A combination of steel and precast concrete members may sometimes form an economical and easily constructed building frame. Precast concrete columns are usually cheaper than steel columns if they have to be designed to take both vertical and lateral loads. Steel may on the other hand be more suitable for long spans. There is no special difficulty in designing such a combination structure and our firm has built several of them. It is much easier to design a joint between a steel member and one of concrete than it is to design a good joint between two precast concrete members. For this reason and because of the large number of possible variations, examples of such joints will not be given in this paper. It is important also in this case that the design should be such that there are projections only on one side (upwards) when the concrete member is cast. This will facilitate the side by side casting mentioned previously. Fig. 8 shows part of such combination steel-precast concrete structures.

Conclusion

The question may be asked what further developments are possible in the jointing of precast concrete members. The writer thinks that this will depend largely on the increased use of welding of reinforcing bars. At the present time welding of reinforcing bars for taking tension is seldom used in North America. Comparatively little attention has been given to the weldability of reinforcing steel and there are not even any suitable code provisions as far as the writer knows. Until further investigations have been made it seems risky to depend unduly on a welded splice and especially on the butt welded type. Steel with high carbon content is difficult to weld without considerable loss of tensile strength. Undesirable as the lap splice is in many respects, it is probably still the most reliable form for a splice. It is for the above reasons urgently required that a thorough investigation be made of the possibilities and limitations of welding of steel reinforcement.

Fig. 8. Combination steel-precast concrete structure



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K_2O

WESTERN CANADA POTASH AND ITS FUTURE PROSPECTS

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

The term "potash" is applied to the compounds of the element potassium and is expressed in the term of potassium oxide (K_2O). Potassium oxide is not found in nature nor produced by man, but is used as a basis for comparison of all potassium compounds and is applied generally to the various compounds of potassium used by agriculture and industry. Potassium is one of the most essential chemical elements used by man. In 1959, 95% of the potash consumed in North America was used for fertilizer and the balance for industrial and chemical uses. Potassium chloride, known commercially as muriate, is the major potash compound used in fertilizer, the other compounds used are sulphate of potash and sulphate of magnesia. Chemical grade potassium chloride containing over 99.9% KC1 is the basic compound for most chemical and industrial uses. Potassium hydroxide, produced from potassium chloride, serves as the basic chemical for manufacturing many potassium compounds. The major industrial uses of potash are in detergents and soaps, glass and ceramics, textiles and dyes, chemicals and drugs, and refining and purification processes.

THE GREATER part of the world's supply of potash is derived from deposits of soluble potassium minerals such as occur in western Canada and New Mexico. There is, however, some production from concentrated surface brines, for example, at Searles Lake, California; Salduro Marsh, Utah; the Dead Sea; and from well brines in Michigan.

Up to the outbreak of World War I the German potash industry, which was developed in the period 1861-1865, was the sole source of potash for North American agriculture and industry. During the war years the United States was forced to get what potash it could from a number of expensive sources such as brine lake, distillery wastes, flue dust and seaweeds. The price rose from $35 a ton to almost $500 a ton. In 1925 while exploring for oil east of Carlsbad, New Mexico, the Snowden and McSweeny Company discovered potash salts. The United States Potash Company was formed to develop the deposit and production of potash began in 1931. At the present time there are six mines in operation in the Carlsbad area of New Mexico with an annual production in excess or two million tons K_2O. The mine production from this area for 1958 was 2,309,000 tons K_2O.

Discovery of Potash in Saskatchewan

Potash mineralization in Saskatchewan was first recognized in a core from the Norcanols Radville No. 1 well (Lsd. 36-5-19-W2), drilled early in 1943 near Radville in southeastern Saskatchewan. In the same year, potash was observed in Norcanols Ogema No. 1 well (Lsd. 24-7-23-W2). The potash-bearing beds occurred in these wells at depths of 7,653 ft. and 7,420 ft. respectively, and the discoveries were not of interest for commercial production of potash. In 1946 core grading 21.6% K_2O over 11 ft. was recorded from Verbata No. 2 (Lsd. 24-21-24-W3), drilled near Unity in west central Saskatchewan. In this well the potash was encountered at a depth of 3,466 ft. and the possibility of commercial production was considered.

In 1950 companies engaged in oil exploration began running logs measuring the natural radioactivity of the formations penetrated and this provided a new tool for the search of potash. Potassium has one isotope K_{40} which emits intense gamma rays (Ahrens and Evans, 1948) which give rise to high radio activity being recorded on the log opposite potash bearing formations. These logs indicated the existence of potash-rich beds over a large area of southern Saskatchewan.

Geology and Mineralogy of the Saskatchewan Deposits

The potash in Saskatchewan is of Middle Devonian age and occurs in beds near the top of the Prairie Evaporite formation of the Elk Point group. A Middle Devonian age has been confirmed by potassium dating methods (Folinsbee, Lipson, and Reynolds, 1956). The Prairie Evaporite formation was deposited in the Elk Point basin (Baillie, 1953), which trends northwest-southeast from North Dakota and southwestern Manitoba into eastern Alberta. The basin is structurally closed except to the northwest.

The Elk Point group consists of, in ascending order, the *Ashern formation* (shale: red and green shale, subordinate gray shale, dolomitic and calcereous); the *Winnipegosis formation* (Dolomite: tan saccharoidal dolomite, minor standard carbonate, sporadic inclusions of evaporite near top); and the *Prairie Evaporite formation*

(Evaporite: potash, salt, and anhydrite). The group is underlain by older Paleozoic formations and overlain by the *Second Red Bed* of the Dawson Bay formation. The Second Red Bed, which is an argillaceous layer consisting of red and green shale and subordinate gray shale (dolomitic and calcereous), forms a distinctive marker horizon above the Prairie Evaporites.

The Prairie Evaporite formation consists mainly of massive halite with clay and anhydrite interbedded throughout. Varying amounts of anhydrite and dolomite occur near the base. The salts vary in texture from fine grained to very coarse grained, the latter being found chiefly in the upper part of the formation. The formation extends from northern Alberta, across central and southern Saskatchewan, and into Manitoba for a few miles. In the south central part of the area there is a section in which the salt has been removed by solution and the younger formations above have collapsed. Geophysical data indicate that there are solution channels in the salt formation. The Prairie Evaporite formation is over 600 ft. near the centre of the basin and thins to less than 50 ft. around the margins. The formation does not outcrop and at the northern edge the salt is found at depths of 2,500 to 2,800 ft. below the surface. The beds generally dip gently in a southerly direction.

The potash mineralization occurs within the upper 200 ft. of the Prairie Evaporite formation. Information obtained from bore holes drilled specifically for potash indicate that there are several distinct potash-bearing horizons or zones. Goudie (1957) identified three major zones. In addition to these there may be one or more lesser ones. Each zone contains one or more potash-rich beds interlayered with barren salt or beds with low potash content. However, the three major zones are not encountered in all test holes. The available well information indicates that the area of deposition of the earliest potash zone was more restricted than the later ones. A number of sub-basins developed in the Elk Point basin. According to Goudie (1957) during the first major period of potash deposition, three of these, designated as the Esterhazy, Ellisboro, and Moose Jaw-Regina sub-basins, appear to have been in existence. Others developed during the other major cycles of potash deposition.

There are three predominant minerals occurring in the potash-bearing formation, halite (NaCl), sylvite (KCl), and carnallite ($KCl.MgCl_2.6H_2O$). Halite and sylvite occur together as the mechanical mixture known as sylvinite. Sylvite is the desirable mineral from the point of economics as it contains 63.2% K_2O equivalent, while carnallite contains only 16.9% K_2O. Polyhalite ($K_2SO_4.MgSo_4.2CaSO_4.2H_2O$) and leonite $MgSo_4.K_2SO_4.4H_2O$) have been reported from a few wells. The main potash minerals, sylvite and carnallite, occur separately and in close association. In different localities or areas the sequence of occurrence is not always the same. In some wells the upper beds may be predominantly carnallite grading down into those higher in sylvite, while in others the sylvite occurs predominantly above the carnallite-bearing beds, or sylvite may be the main mineral throughout. For example in the wells, Quill Lake No. 1 and Quill Lake No. 2, just to the west of the Quill Lakes, the uppermost bed contains mainly sylvite and halite and the lower beds contain essentially carnalite, while in a well, Flint Edmore Crown No. 2, about 25 miles southeast of Big Quill Lake, carnallite occurs in the upper bed and sylvite with carnallite appears below. Generally the clay content appears to be higher in the western and central parts of the potash area than in the eastern section.

Grades and Reserves

The grade of potash found in Saskatchewan and Manitoba is generally higher than the potash being mined in New Mexico and Europe. The best ore of New Mexico grades from 20 to 25% K_2O. However, as mining is carried on, the higher grade ores are depleted first. The United States Bureau of Mines reports that the calculated grade of the crude salts mined in 1958 was 18.89% K_2O compared with 19.30% in 1956 and 20.7% in 1947. The grades in the Stassfurt deposits in Germany range from 10 to 20% K_2O. The commercial grade in Saskatchewan probably will be in the 25 to 35% range.

Drilling to date had indicated that the potash deposits in Saskatchewan are very extensive and that the total potash in the Prairie Evaporite formation probably exceeds previously known world reserves. In Saskatchewan the recoverable reserves at depths of less than 3,500 ft. and grading 25% or better, with bed thicknesses limited to 5-10 ft. have been estimated at 6.4 billion tons. In making this estimate a recovery of 40% of the ore from only one bed in zones of multiple beds and 90% mill efficiency was assumed. However, if a brining technique can be developed which will extract potash economically, potash-bearing deposits at greater depths than 3,500 ft. will become commercial reserves and the economic potash reserves of the province will be increased greatly.

Development of Potash in Saskatchewan

The first commercial production of potash in Saskatchewan was attempted by Western Potash Corporation Limited (Continental Potash Corporation Limited, 1955) on land acquired in the Unity district approximately 100 miles west of Saskatoon. The company attempted to develop a method of mining potash salts by solution similar to that used in producing comon salt, but the experiment proved unsuccessful. A shaft located approximately eight miles northwest of Unity, was begun and by February 1958, when operations ceased, had reached the top of the Blairmore formation at a depth of 1,675 ft. In June 1959, operations on the shaft were resumed. A test hole was drilled 230 ft. west of the shaft for the purpose of making a study of the Blairmore formation. Tests carried out on sections of this formation indicate that the shaft can be extended successfully through it.

Potash Company of America was the first of the producers from New Mexico to begin exploration in Saskatchewan. By the end of 1953 the company had selected an area east of Saskatoon and from that time exploration for potash accelerated rapidly. In 1954 Potash Company of America started preparations for shaft sinking, which included freezing the shaft area to a depth of 3,000 ft. at Patience Lake, approximately 16 miles east-southeast of Saskatoon. The shaft was completed in June 1958 to the 3,450 ft. level and the main operating level was established at 3,333 ft. Production began in November 1958 and the first shipment of muriate of potash was made in March 1959. The plant continued to operate until November 1959 when production was suspended due to water seepage into the shaft. A program of grouting and shaft repairs was initiated, which entails the gradual thawing of the frozen area surrounding the concrete shaft lining and grouting as the thaw takes place. The grouting program may take up to one year to complete.

International Mineral & Chemical Corp. (Canada) Ltd. which holds a reservation and lease on the east side of the province in the Esterhazy area, entered the field in 1955 and shaft sinking was begun in the spring of 1957 at a site approximately 12 miles northeast of Esterhazy. By June, 1958 the shaft had reached the top of the Blairmore formation at a depth of

1,200 ft. An attempt was made to sink the shaft through the Blairmore without prefreezing the shaft area and by using a grouting technique, but this method proved unsuccessful. The present operations involve freezing of the Blairmore to —50° F. and when this is completed the shaft sinking will be resumed using a technique called "tubbing". This involves lining the shaft through the water-bearing formation with a water-tight cast iron lining, composed of a series of 65 rings, each 5 ft. high, about 4 in. wall thickness, and 18 ft. diameter, which will be joined and sealed with lead and bitumen. When the cast iron section has been completed the frozen area will be permitted to thaw out. Haniel and Lueg, a German engineering firm, will direct the installation. It is expected that potash production will begin in late 1961.

The water-bearing Blairmore formation so far has been one of the main problems in shaft sinking and shaft construction. However, by employing shaft-sinking methods used with success in other parts of the world where similar conditions exist there is not much doubt that this problem can be overcome by future producers in the potash field.

As of May 1, 1960 there were 15 companies representing Canadian, American, British, German and French interests holding a total of 1,326,590 acres under potash disposition.

With the extensive exploration for potash that has been carried on in the last few years the main activity is centered in two areas. The one area extends from about 30 miles west of Saskatoon to the Quill Lakes in a belt 30 to 35 miles wide, and the other extends from south and southwest of Yorkton, southeast across the Saskatchewan-Manitoba boundary into Manitoba for a few miles over an approximate width of 25 to 30 miles. However, the most recent withdrawals of potash lands have been in an area between Moose Jaw and Regina, and one west of the northern part of Last Mountain Lake about 46 miles north of Moose Jaw. One potash permit is held in the Unity area.

World Production and Consumption of Potash

The first recorded production of potash was in Italy in 1816, where alunite $(K_2Al_6.(OH)_{12}(SO_4)_4$ was mined to produce alum. Potash salts were noted in Poland at Kalsz in 1854, but continuous production from Polish deposits did not begin until 1920. Soluble potash salts were first produced in Germany in 1861 and by 1865 Germany had developed a potash industry. Alsace began production of potash salts in 1910, Spain in 1925, Russia in 1930, and the United States in 1931 (although potash production from brines had begun in the United States in 1915 when the potash supply was cut off from Germany during World War 1). There was some production from brines from the Dead Sea in 1930. In addition, Japan, China, Ethiopia, Italy and Korea are reported to produce minor amounts of potash salts. Production in Europe had dropped from approximately 3,520,000 short tons K_2O in 1941 to about 1,500,000 short tons by the end of World War II. However, since then there has been a steady increase in potash production. Table I gives the world production of marketable potash in equivalent K_2O by main producing countries from 1949 to 1958. World production of potash in 1958 totalled approximately 8.8 million short tons.

Free world consumption of potash increased from 2,776,000 short tons in 1938 to 7,666,000 tons in 1957. The North American consumption in 1938 was 428,178 short tons and by the end of 1959 the total consumption had risen to 2,787,367 tons, approximately 6.5 times what it was in 1938. Canadian consumption in 1950 was 62,181 tons while in 1959 it was 96,411 tons, of which 29,441 tons were imported from Europe. In 1958 the United States imported 237,269 tons K_20 and in 1959, 268,002 tons K_2O equivalent. Exports of North American potash to other countries in 1959 showed an increase of 36% over the previous year. Deliveries of potash in 1959 for agricultural pur-

TABLE I

World production of potash (marketable, unless otherwise stated) in equivalent K_2O, by countries

(1) 1949-53 (average) and 1954-58, in short tons (2) (Compiled by Helen L. Hunt and Bernice B. Mitchell) (Modified) Foreign Statistics, Division of Foreign Activities, Bureau of Mines, May 4, 1959

Country (1)	*1949-53 (average)*	*1954*	*1955*	*1956*	*1957*	*1958*	*% of World Production*
North America: United States	1,480,689	1,948,721	2,066,706	2,171,584	2,266,481	2,147,670	24.4
Crude (including brines) (3)	1,619,004	2,170,969	2,326,946	2,479,463	2,615,808	2,478,724	
South America: Chile	3,650	550	11,000	12,000	11,000	(4) 11,000	
Europe:							
France	1,191,387	1,192,083	1,310,961	1,463,006	1,545,267	(4) 1,613,000	18.3
Crude (3)	1,099,382	1,361,734	1,490,764	1,653,465	1,736,800	1,882,039	
Germany:							
East (4)	1,387,800	1,488,000	1,582,000	1,598,000	1,653,000	1,700,000	19.3
Crude (3) (4)	1,602,800	1,720,000	1,820,000	1,840,000	1,900,000	1,960,000	
West	1,189,900	1,783,394	1,870,848	1,823,000	1,862,000	1,892,000	21.5
Crude (3)	1,420,650	2,135,000	2,227,000	2,166,000	2,190,000	2,222,000	
Spain	187,626	243,166	242,539	263,468	251,460	(4) 236,000	2.7
U.S.S.R. (4)	377,600	593,700	870,500	983,600	1,040,000	1,100,000	12.5
Asia:							
Israel	683	(4) 12,000	(4) 12,000	(4) 31,000	(4) 50,000	(4) 80,000	0.9
Japan	234	454	461	474	(4) 1,650	(4) 1,900	
Africa: Eritrea	786	—	—	—	—	—	
Oceana: Australia	369	—	—	—	—	—	
World Total (marketable) (estimate)(1) (2)	5,800,000	7,300,000	8,000,000	8,300,000	8,700,000	8,800,000	

(1) In addition to countries listed China, Ethiopia, Italy, Korea, and Poland are reported to produce potash salts, but statistics of production are not available, estimates are included in totals.
(2) Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.
(3) To avoid duplication of figures, data on crude potash are not included in the total.
(4) Estimate.

poses in the United States, Canada, Cuba, Puerto Rico, and Hawaii were four per cent higher than in 1958 and deliveries for non-agricultural purposes were 24% higher. Total deliveries for all purposes, containing 2,787,367 tons K_2O, were 8% higher. The potash consumption in parts of Asia is extremely low and no doubt will have to be increased greatly in the near future if sufficient food is to be supplied to ever growing populations. For example, in 1950, India consumed 2,205 tons of potash and by 1957 the consumption had increased to 29,106 short tons, which is still a small amount for a country of that size.

Grades and Prices of Potash Marketed

In 1959 in North America muriate of potash (KCl) comprised 94% of the agricultural potash. Sulphate of potash and sulphate of potash-magnesia accounted for the remaining 6% of agricultural deliveries. The potassium chloride, as the 60-63% muriate, is produced in three grain sizes — standard (28— to 150 mesh), coarse (10— to 28— mesh) and granular (8— to 20 mesh) and as manure salts containing 20 to 22% K_2O. The potassium sulphate contains a minimum of 50% K_2O and the potassium-magnesium sulphate (Sul Po-Mag) contains 22% K_2O and 18% MgO. A chemical grade of potassium chloride with less than 1% impurities is also produced and is used as the basic material for the production of other potassium compounds used by the chemical industry.

Prior to the development of the potash industry in the U.S. importers sold potash on the basis of 60% K_2O with adjustments if the K_2O content were more or less. Shipping costs were equalized at the Atlantic and Gulf ports. There were discounts for quantity, which were discontinued prior to 1930, and seasonal discounts for deliveries between July 1 and October 1.

When the U.S. producers went into production this price structure was in existence, but in 1934 the 60% K_2O basis was increased to 62½%. The "20-lb unit" basis replaced the tonnage basis. On this basis the price per ton is calculated by multiplying the percentage of K_2O by the price per unit. At the present time different prices are in effect for different times of the year. This pricing system promotes early contracting, enabling the producers to schedule the output more evenly throughout the year. Since the development of the potash industry in New Mexico potash prices have remained relatively stable.

All the producers in the U.S. issue price schedules annually. Prices are for minimum 40 ton lots, f.o.b. mine per unit K_2O. For example, the following prices were quoted for agricultural potash for the season July, 1958 through June 30, 1959:

For Shipment	*Standard*		*Granular*		*Sulphate of Potash 50% K_2O Min.*
	Muriate-bulk 60% Min. K_2O-per unit	*Bagged 60% Min. per ton*	*Muriate-bulk 60% Min. K_2O-per unit*	*Bagged 60% Min. per ton*	
July, 1958	30c	$22.90	30.5c	$23.20	59.5c
August, 1958	30c	$22.90	30.5c	$23.20	59.5c
September, 1958	31c	$23.50	31.5c	$23.80	59.5c
October, 1958	31c	$23.50	31.5c	$23.80	64.5c
November, 1958	32c	$24.10	32.5c	$24.40	64.5c
December, 1958	32c	$24.10	32.5c	$24.40	64.5c
Jan. thru May incl. 1959	34.5c	$25.60	35.0c	$25.90	67.5c
June, 1959	30c	$22.90	30.5c	$23.20	64.5c

Source: Potash Company of America Limited.

The prices above applied only to tonnage contracted for prior to July 1, 1958. On tonnage contracted after July 1, 1958 the basic price was increased by 2c per unit K_2O on bulk shipments and $1.20 per ton on bagged shipments. The price of mine-run salts, 22% K_2O minimum, per unit of K_2O for shipment in any month regardless of when contracted is 17.65c. All the prices are f.o.b. cars, Carlsbad, New Mexico, or f.o.b. cars P.C.A. Siding, Saskatchewan, with shipment from either point at seller's option. The freight charges were to be equalized if the freight rates from the Canadian shipping point to points in the United States were higher than from the Carlsbad seller.

Recently one U.S. company announced that it will increase prices on all its agricultural grades of potash after July 1, 1960. The prices will be as follows:

For shipment	*Standard Muriate "Higran" (62%-63% K_2O) per unit*	*Coarse Muriate "Hygran" (62%-63% K_2O granular Muriate (60% K_2O) per unit*
July-Aug., 1960	33c	34c
Sept.-Oct., 1960	34c	35c
Nov.-Dec., 1960	35c	36c
Jan.-June, 1960	37½c	38½c

Bag prices for all grades are $5 ton higher.

Markets and Future Outlook

The greatest demand for potash will continue to be for fertilizers and the demand may be expected to increase with the long term growth in agriculture. The potash industry in the United States predicts that the North American capacity will more than double by 1970-71. Thus it can be expected that approximately 4,700,000 tons K_2O will be consumed annually by that time on this continent. Further, The Royal Commission on Canada's Economic Prospects states that "A minimum of eight million and a maximum of ten million tons K_2O must be supplied if Canadians and Americans are to counteract soil losses twenty-five years hence". Thus the predicted minimum requirement for Canada and the United States in 25 years is only slightly less than the total world production of potash for 1958 (8.8 million tons).

The Western Canada potash industry should compete well in the world market with the established potash industries in the United States, Germany, Russia, Israel-Jordan, France, and Spain. Saskatchewan and Manitoba are in a preferred location to supply the American Midwest market because potash from these provinces will be competitive with the New Mexico deposits as far south as Virgina. The United States Midwest is one of the largest concentrated markets for potash in the world. In 1959 six midwest states accounted for the consumption of 797,870 tons K_2O out of a total of 2,165,581 consumed by the whole United States. Potash consumption in each of these states was as follows:

State	*Tons K_2O**
Illinois	227,039
Indiana	180,459
Iowa	66,434
Minnesota	76,200
Ohio	174,516
Wisconsin	73,322
Total	797,870

* American Potash Institute (to nearest ton)

Other states in this area which would become markets for Canadian potash are North Dakota, South Dakota, and parts of Montana. Western Canada can compete with New Mexico for at least 40% of the U.S. potash market.

The expansion of the Canadian potash industry will be dependent on developments in other potash producing countries and potential producing territories, such as Germany, and Utah in the United States, and also on the expansion of the consuming areas which are deficient in potash such as parts of Asia, Africa, Australia and New Zealand. Areas in Asia which particularly will require potash are Japan, India, Pakistan and China. Japan could become a large market for Saskatchewan potash. The major factor determining Saskatchewan's competitive position relative to West Germany in supplying the Asiatic market will be the cost of the rail haul to Vancouver. During 1959 Potash Company of America Limited completed contracts for bulk sales to Japan. The first shipment of Canadian potash to Japan was scheduled for last July. The construction of a bulk loading dock at Vancouver, should improve Saskatchewan potash producers' competitive position in Far East markets. Other potential markets are Australia, New Zealand and other Asiatic countries such as Korea and parts of China. Too much cannot be expected in the European markets because the potash deposits in Germany and Israel-Jordan are well situated to serve these.

Factors Conducive to Increased Potash Consumption

There are a number of factors which will have a pronounced influence on the future of potash production and consumption, not only in Western Canada but in other potash-producing countries. Some of these are listed below:

1. There will be a considerable increase in the populations' total needs. As population growth continues upward, farmers must produce more out of each crop;

2. Movement of farm labour to cities will deplete farm manpower to the extent that greater mechanization must be used and therefore greater quantities of fertilizer;

3. Expanding cities and towns will decrease the number of acres of land under cultivation. As a result there must be more intensive cultivation of the remaining acreage;

4. India and Pakistan, trying to overcome food shortages for their extremely large and ever growing populations, will require large quantities of fertilizer;

5. The communization program in China will probably be responsible for large increases in the amount of farm mechanization, which in turn will require greatly increased amounts of potash;

6. The nationalization of many African territories could call for more intensive agricultural programs involving greater use of potash;

7. Programs which are advocated in the United States and might well be adopted in other countries which will help boost potash consumption are as follows:

(a) Forage crop fertilization: As the population increases more meat is required, which in turn requires more forage crops;

(b) Forest fertilization: As the country's lumber and paper mills and cellulose manufacturers use more and more fibres, forest growth must be accelerated by using fertilizer application;

(c) Non-farm fertilization: With the expansion of the suburban population there will be more emphasis on space in parks and around public buildings requiring heavy landscaping expenditures and as a result an increase in fertilizer consumption can be expected in the future.

Summary

The long term prospects for potash in general are good. Factors such as the fast-growing populations in various countries, particularly those of Asia, and the nationalization of many African territories, combined with rapid growth rates, will call for more extensive agricultural programs, involving greater use of potash to increase food production.

The future of the Western Canadian potash industry is very promising. The immense reserves and high grade of the potash, as well as the favourable location with respect to some of the large markets and potential markets make the Canadian deposits very attractive to potash producers from other countries. Apart from the fact that there will be an increase in potash consumption in many parts of the world in the years ahead, the reserves of a number of the other potash-producing countries are decreasing. The grade of the reserves in some of these countries is becoming lower. For example, in New Mexico the grade in 1947 was 20.7% K_2O and by 1958 is was 18.89% K_2O. Therefore as the reserves decrease and grades become lower potash producers will eventually have to seek new sources from which they can carry on production. Western Canada will be the obvious choice because of the size of the commercial reserves and the grade of potash which is higher than the best both in Europe and the United States. Because of the higher grade of the Canadian ore, production costs should be less than those in New Mexico, particularly. A further inducement making potash mining in Canada attractive is that there is an exemption from taxes the first three years after commencement of production.

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IRRIGATION LAND DEVELOPMENT POLICIES FOR SASKATCHEWAN

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Although Jacobson[1] under experimental control on the Bow River Irrigation Project at Vauxhall, Alberta was able to produce in excess of 5 tons (Fig. 1) of alfalfa per acre the average yield on the project itself was in the neighborhood of 1.7 tons. Stewart[2] in 1953 therefore planned Farm Use of Water Studies in an attempt to determine the cause of this low production. This project was laid out in such a manner that it was possible to determine approximately the amount of water delivered, moisture holding capacity of the soil at the time of irrigation, runoff, and to a limited degree deep percolation and water distribution on the field. After only two summers it was concluded to obtain accurate results was almost an impossibility as less than 25% of the water diverted was going to plant use and the remainder to runoff or deep percolation. The efficiency of application was therefore less than 25%.

ENGINEERS for decades have used the term efficiency to convey to their associates a measure of performance of men, machines or equipment. It is therefore not surprising to find that Israelsen[3] a pioneer in the irrigation field proposed the term *Water Application Efficiency* and defined it as follows:

$$\text{W.A.E.} = 100\,\frac{\text{Stored Water}}{\text{Delivered Water}}$$

or in algebraic terms

$$E_a = 100\,\frac{W_s}{W_f}$$

where
E_a = water application efficiency
W_s = water stored in soil root zone during irrigation
W_f = water delivered to the farm.

This concept has been widely accepted and is now in general use.

As Irrigation Science has advanced over the decades and more and more emphasis placed on increased production Israelsen's definition has been found quite inadequate. Situations where the water distribution was uneven, or where insufficient irrigation water was applied at any particular irrigation, were not evaluated realistically. This was the situation at Vauxhall, Alberta although the runoff and deep percolation were so large it was difficult to assess the magnitude of poor distribution on the field and throughout the season. Insufficient irrigation water was also common. Considering the former, it was possible and indeed quite a reality on the rougher land to obtain an efficiency of 50% for the average of the field and at the same time to reach 100% in areas of low application. For the latter it was apparent that any amount diverted which is less than the storage capacity of the soil gives 100% efficiency. The less the amount diverted the greater the probability of reaching 100% even though this type of water application would not provide a suitable moisture environment for the crop nor would it be desirable from the standpoint of the efficient use of labour.

The growing scarcity of water in the United States and the desire for irrigation and drainage improvement prompted Hansen[4] to present three new irrigation efficiency concepts, *Water Storage Efficiency, Water Distribution Efficiency* and *Consumptive Use Efficiency*, defined as follows:

Water Storage Efficiency (W.S.E.) —

$$100\,\frac{\text{Stored Water}}{\text{Needed Water}}$$

algebraically $E_s = 100\,\dfrac{W_s}{W_n}$

where
E_s = water storage efficiency
W_s = water stored in root zone during irrigation
W_n = water needed in the root zone prior to irrigation

Water distribution efficiency (W.D.E.)

$$= 100\left(1 - \frac{\text{average deviation}}{\text{average strength applied}}\right)$$

or $E_d = (1 - y/d)$
where
E_d = water distribution
y = average numerical deviation in depth of water stored from average depth of water stored during the irrigation.
d = average depth of water stored during the irrigation

Consumptive use Efficiency (C.U.E.)

$$= 100\,\frac{\text{Consumptively use water}}{\text{depleted water}}$$

or $E_u = 100\,\dfrac{W_u}{W_d}$

where
E_u = consumptive use efficiency
W_u = water used consumptively
W_d = depleted water

Experimental Observations

An irrigation project to be a success not only to those involved in the planning but also to the farmer who is directly associated with the water application must produce substantially higher yields than neighbouring dry land farms. To obtain this high degree of production it is essential that the growing crops receive moisture according to their consumptive use requirements. In the Prairie Region this involves, on the average, three irrigations per year and further requires the supplemental water be applied uniformly throughout the field, neither a shortage nor an excess. In other words, it is essential that not only the water application efficiency should be a high percentage but the water storage efficiency, the water distribution efficiency and the consumptive use efficiency should likewise be of a realistic magnitude.

In addition to these low efficiencies on the Bow River Project irrigation water was applied at the average rate of five acres per day. The farmer who had 160 acres required 30 days to irrigate once and 90 days for the required three irrigations or 120 days for four applications of water. Consequently, not many farmers applied more than a single irrigation. The major reasons for this alarming situation were:

1. Land requiring up to 500 yd. of levelling per acre was under the ditch. The difficulty of attempting to surface irrigate land with no preparation and requiring this amount of levelling would appear to be fairly obvious;

2. Farms have adopted practices for applying water which were outdated. It is rather difficult to interest farmers, for that matter any one, to change their technique when considerable capital investment is required;

3. Farmers had insufficient knowledge about irrigation. In comparison with the knowledge farmers have of livestock, machinery, etc. they knew very little about modern methods of the artificial application of water, infiltration, water storage in the soil, crop requirements, etc;

4. The farm distribution systems were undersigned. This requires greater correlation on the part of the designing engineers and those operating the project. Farmers of the future should look forward to applying three inch irrigations to 30 acres per 8 hour day, with an application efficiency of 75%.

Land Preparation and Crop Returns

Insufficient surface and subsurface drainage, poor land preparation, low water application efficiency, salinity, and net farm income were so complexly related that it was difficult to explain their interrelation without at least two or three graphs. Unfortunately, sufficient scientific data is not available in Western Canada to compile these graphs accurately. The following have, however, been compiled from the available scientific data plus scientific observation from Alberta projects.

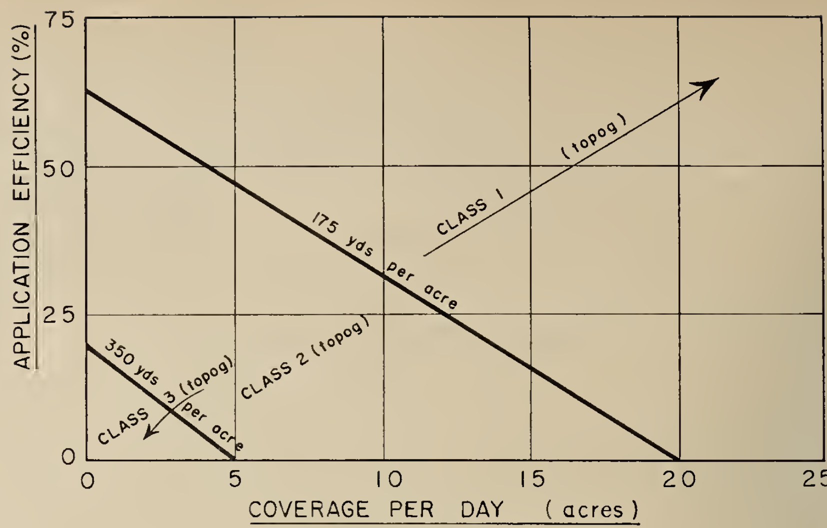


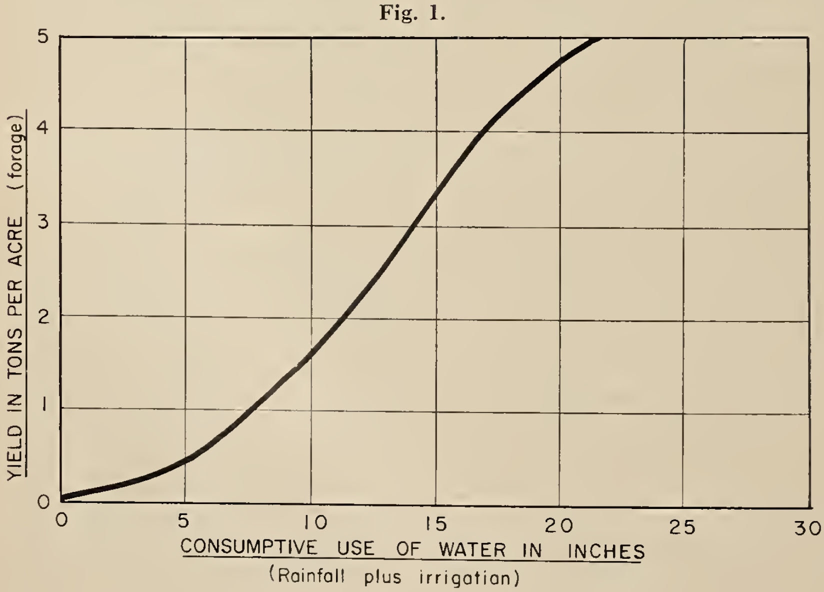
Fig. 2.

Fig. 2 and Fig. 3 make use of the United States Bureau of Reclamation topographic classification — Class 1 topography up to 175 yd. per acre, Class 2 topography from 175 to 350 yd. per acre, and Class 3 from 350 to 650 yd. per acre.

Fig. 2 is intended to convey the relationship between the three variables application efficiency, coverage per day and topography in a more or less qualitative manner only. It is not possible to say just how accurate this graph is over the ranges indicated but from experience in Alberta these concepts are sufficiently important in dealing with irrigation problems that an attempt should be made to express them.

Fig. 3 is based on the costs of moving earth at 20c per yd. for average cuts. When the yardage per acre increases to the upper limit the costs drop to about 16c per yd.; when the yardage per acre decreases to the lower limit the costs rise considerably above 20c. Levelling in the range of Class 1 seldom requires an additional finishing in succeeding years of use as does Class 2; this accounts for a larger area for Class 2 than Class 1. The additional cost required to handle 30 acres per day in lieu of fifteen at the same efficiency is due to the greater precision required in finish levelling. In other words where an accuracy of cut or fill of two-tenths may be sufficient for a coverage of 15 acres per day less than one-tenth would be required for 30 acres per day. This finish levelling is expensive on a yardage basis.

Fig. 1.



Consider three farms each of 160 acres with three farmers of identical managerial capacity. Farm A requires 350 yd. per acre land levelling, farm B 175 yd. per acre and Farm C 100 yd. per acre. These yardages are considered necessary to bring each farm to optimum preparation.

Farm A — 350 yd. per acre preparation: If four acres are irrigated per day (Fig. 2) the efficiency is approximately 10%. If 10 in. is diverted then 1 in. is stored and 9 in. created a surface and sub-surface drainage problem. At four acres per day it requires 40 days to irrigate, consequently the farm is irrigated only once. From Fig. 1, ten inches of rain *plus one inch irrigation gives a net return of 1.7 tons per acre.

Farm B — 175 yd. per acre preparation: If four acres irrigated per day (Fig. 2) with an efficiency of 50% and 6 in. diverted, then 3 in. is stored and only 3 in. contribute to drainage. With one irrigation (ten inches of rain plus three inches irrigation) a net return of 2.5 tons per acre is possible. With two irrigations and eight acres per day, returns are the same.

* Assuming effective rainfall for consumption use of ten inches.

Farm C — 100 yd. per acre preparation: If ten acres are irrigated per day (Fig. 2) with an efficiency of 50% and 6 in. diverted, 3 in. are stored and 3 in. create a drainage problem. If ten acres are irrigated per day it requires only 16 days to irrigate and no doubt two irrigations will be applied. Ten inches of rainfall plus two 3 in. irrigations (total 16 in.) gives a return of 3½ tons per acre. In general more water is diverted for each irrigation as the topography becomes poorer.

Consider that the three farms are prepared to good standards and the efficiency will approach 75%, also that four irrigations are applied. If each irrigation stores three inches (10 in. rain plus 12 in. irrigation) the returns are better than five tons per acre. The effects of removing surface soil through levelling and not replacing it are of considerable concern at the present time to Soil Scientists. Experience in Alberta on the 20,000 acres levelled would indicate the greatest problem occurs when the lime zone becomes the new surface. These effects however disappear in about three to five years. Many authorities feel levelling is essential even with its adverse effect on structure and fertility due to the improved application efficiency, labour efficiency and the resultant decrease in drainage problems.

There are an unlimited number of these combinations of variables and assumptions which can be considered. The same conclusions would be evident.

1. Efficiency falls off with poor preparation. As the need for heavy levelling and improved surface preparation increases the application efficiency, distribution efficiency, storage efficiency and possibly the consumptive use efficiency fall off;

2. Number of irrigations per year decreases with increased need for preparation. As the need for preparation increases so does the length of time required to apply water until such time as the coverage per day decreases to 2 or 3 acres. If the farmer has a reasonable number of so called irrigable acres it eventually becomes a physical impossibility to cover the area more than once if he is to give any attention to other farm operations;

3. Surface and sub-surface drainage problems are aggrevated by poor land preparation. As the efficiency decreases the surplus water is removed either by surface or sub-surface methods. Surface water is perhaps the least serious as the main consideration is waste of water. Sub-surface drainage however, is much more of a problem as the cost of sub-surface drainage varies almost directly with the amount of water to be removed. If the contribution of sub-surface water is extreme it becomes physically impossible to supply sufficient artificial sub-surface drainage;

4. Low returns on land which is difficult to irrigate. It is rather difficult to assess all the factors causing low returns such as physical, chemical, managerial, etc. but it would appear that in general the high areas suffer an extreme lack of irrigation water, the low areas an extreme excess and the fairly uniform areas a deficiency of water mainly from an insufficient number of irrigations;

5. Unless some adjustment is made in price of land, or water rate, then the farmer on Farm C has a decided advantage. Farm C would provide the optimum gross returns with $50 per acre land preparations whereas Farm B would require $100 per acre and Farm A $150 per acre.

Recommendations and Development Policies

It would appear that the following recommendation would alleviate on the South Saskatchewan Project most of the above difficulties which are common to irrigation projects in Western Canada.

1. Establish a South Saskatchewan River Irrigation Board, which would be responsible for the correlation of the dam construction, land classification, land acquisition and allocation, distribution system, land development policy, extension, and administration until approximately ten years after the project is in operation;

2. Irrigate only land that can be developed for a maximum of $100 per acre (this would give an average cost of approximately $75 per acre). If the cost of land preparation decreased due to new types of earth moving equipment now on the market it would be expected that larger yardages per acre could be handled;

3. As far as possible have each farmer gain experience in irrigation before he has water delivered to his farm;

4. Develop forty acres per farm unit before the farmer has his first water delivery. Not only will he develop good irrigation practices but it will encourage him rather than discourage him as is so often the case when his land is not prepared;

5. A complete surface drainage system which will permit an outlet to each farm unit to be installed at the time of construction of the distribution system;

6. Provide outlets for farm tile drains, which will be required in a portion of the project area after it is in operation;

7. Establish a charge for a water right in accordance with the class of topography. ($30 per acre — Class 1, $20 per acre — Class 2, $10 per acre — Class 3).

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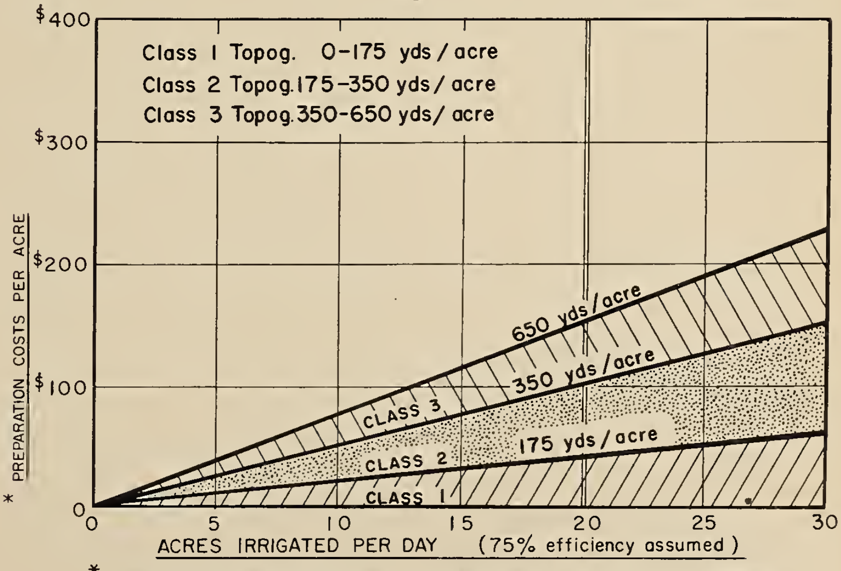
Fig. 3.



* THESE COSTS INCLUDE — ROUGH LEVELLING, FINISH LEVELLING, DITCH CONSTRUCTION, DYKES, SYPHONS OR GATES, AND CULTIVATION AFTER LEVELLING.

Discussion

THE POTENTIAL IN THE FREE PISTON ENGINE PRINCIPLE.

A. Braun, *Vice President,*
Free Piston Development Company, Ltd., Kingston, Ont.
The Engineering Journal, July, 1960, p. 57.

Discussion by James D. Fleming.

In the past five years, many papers have been written about free piston gasifiers. In most of these papers, the advantages of the gasifiers have been oversold. The disadvantages or the difficulties generally go unmentioned. As a result, gasifier performance does not come up to the expectations and the performance of several installations has been disappointing.

In Mr. Braun's paper, the calculated efficiency based on the air standard cycle far exceeds the actual gasifier efficiency. The compressor and turbine efficiencies are completely ignored. The cycle shown in Fig. 3 cannot be used alone. The so-called "by-pass gas" is also part of the working mass and in fact represents a major portion of the energy available. Flow losses, compressor efficiency, and turbine efficiency must be considered for this gas.

The gasifiers now in use run with a volumetric compression ratio of 30 and under. A common error is to multiply the compressor pressure-ratio by the volumetric compression ratio of the diesel section and call this the overall volumetric compression ratio. The relationship is shown below:

$p_r = (cr)^n$
$p_r = 4.5$ (pressure-ratio for the compressor)
$n = 1.38$ (for the compressor)
$cr = 2.98$ (compression ratio for compressor)

Thus when the pressure-ratio for the compressor is 4.5, the compression ratio is 2.98. The compression ratio in the diesel section of commercial gasifiers ranges from a minimum of 6 to a maximum of 10 at full load. The overall compression ratio would then be 29.8 at full load and not 45. The approximate compression pressures for various compression ratios are shown below:

Compression Ratio	Compression Pressure
40	2000 psi
60	3400
80	5000

Compression ratios of 60 and 80, as shown in the paper, are unreasonable. The maximum pressures and temperatures after combustion would be extremely high. The maximum combustion pressures in the GM-14 range from 1500 to 2000 p.s.i.

Mr. Braun has pointed out that the gasifiers will burn a wide range of fuel; however, for efficient operation, the injection system must be tailored for the fuel. Many difficulties have been experienced in using Bunker "C" fuel and the gasifiers will not necessarily run satisfactorily on any fuel that can be injected. Additional equipment such as fuel heaters and centrifuges are required. When heavy fuel is used, wear rates increase.

The "simplicity" of the machine actually complicates its use. There are no rotating parts from which to drive cooling oil pumps, cooling water pumps, fuel transfer pumps, and air compressors. The auxiliary equipment required for a gasifier can be one of the major factors in determining the minimum feasible size for the machine. The turbine cost is also a major factor in determining minimum economical size for a gasifier.

Multiple gasifier installations appear to offer many advantages, especially in flexibility. However, problems of control, line losses, line pulsations, intake pulsations and engine room noise occur. If complete flexibility is to be obtained then each engine room installation which differs from the original poses a new engineering problem.

The gasifiers do have advantages as well as disadvantages and the machines certainly have their place in the power field. The selection of an engine for any application requires a careful analysis of the job requirements and of the operating characteristics of the engines available.

GEOLOGICAL FEATURES AND FOUNDATION TREATMENT AT THE BEECHWOOD DEVELOPMENT

I. D. MacKenzie, M.E.I.C., *Geologist*
E. L. Brown, M.E.I.C., *Field Engineer,*
The Shawinigan Engineering Company Limited, Montreal, Que.
The Engineering Journal, 1959, December, p. 54.

Further discussion: by M. A. J. Matich, M.E.I.C.

The authors are to be commended on a fine paper which is particularly interesting from a foundation engineer's point of view since it describes the course of the work in its entirety, from the geological study of the area and initial exploratory drilling to the completion of the grouting, with even comments on the actual performance of the foundations after treatment.

The data so presented are a useful addition to available information on rock consolidation by cement grouting and it is interesting to compare the results obtained and methods used with the experience of others, including several examples from the records of the firm with which I am associated and which carried out the grouting work in this case. Perhaps a few comments along these lines would be in order.

The information on the pressures used for grouting is of value because it represents a safe departure on the high side from the rule of thumb that the pressure at any elevation should be equal to 1 p.s.i. per ft. of depth. A comparison of the criteria used for the project with published guides for grouting pressure, as apparently employed by the U.S. Corps of Engineers for example, shows that the pressures that actually could be adopted were considerably higher at depths of up to 30 feet than those given in the guides, especially in the stage grouting case. It is recognized of course that the rules of thumb are probably conservative since they do not take into account the physical conditions of the foundation rock and a number of other significant factors such as consistency of the grout and degree of tightness of the hole. Our experience elsewhere in a limited number of cases confirms that pressures considerably in excess of those derived by

(Continued on page 97)

Automation and Control Engineering in Canada

Gas Sampling in the Steel Industry

E. T. W. Bailey

Chief Fuel Research Engineer
The Steel Company of Canada, Limited, Hamilton

Presented at the ISA Symposium on Instrumental Methods of Analysis, Montreal, June 1960.

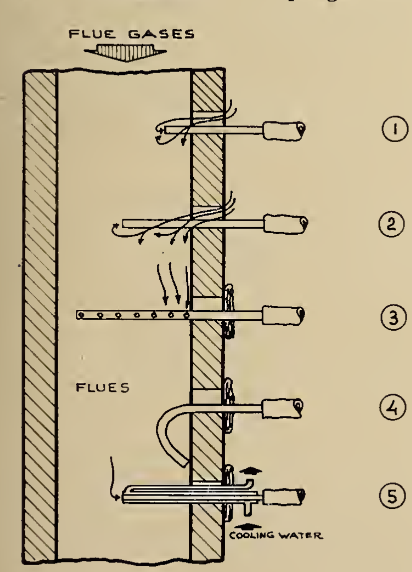
THE principal reasons for gas sampling in the steel industry are the safety of personnel involving the detection of explosive or toxic gases and vapours; the determination of combustion efficiency, air infiltration, dust loading and complete chemical analyses of gaseous mixtures.

Sampling for Safety Tests

In the steel industry the dangerous gases are limited mainly to carbon monoxide. This gas can be present in the fuel or be formed wherever there is incomplete combustion of carbon.

Gases containing carbon monoxide are used in the steel plant for heating purposes. Therefore, it is piped to all sections of the plant, creating plenty of opportunities for contamination of the air in various departments.

Fig. 1. Arrangement of Sampling Tubes.



The following percentage of carbon monoxide is found in the listed fuels:

	Percentage CO
Blast furnace gas	27.7
Bessemer gas	25.0
Open Hearth tap hole	27.0
Cupola gas	17.0
Coke Oven gas	5.9
Mixed Coke Oven and blast furnace gas	8.1
Exhaust from automobile	7.0

Since it is a fact that breathing only four parts of carbon monoxide in 10,000 parts of air can cause collapse in less than two hours and death in three to four hours, the great care that has to be taken can at once be appreciated.

When it comes to sampling, no matter for what purpose, there are truths that must be fully appreciated by those directing the tests. The persons making the tests must have extensive training and experience in order to safely apply the best means to secure a truly representative sample. Any instrument analyser, whether it costs $30 or $3000, is incapable of producing accurate results unless it receives an uncontaminated representative sample.

Before anyone rushes in to secure a sample of atmosphere in any area every care must be exercised that the sampler does not get trapped. Unless he is very familiar with the aspects of the job area where only a gradual build up is possible he should first equip himself with a respirator.

Sampling with such devices as the MSA or Drager carbon monoxide detector tubes can be dangerous. We would very much like to see the manufacturers of this equipment design so samples could be secured from enclosures through a suitable length of tubing without requiring the operator to enter them.

Other precautions must also be taken. For example, a few years ago a steelworker went into a manhole tunnel to open a gas valve. After he failed to appear his partner rushed to get a gas detector. When the detector showed negative results he entered the tunnel. After some time the foreman went to see what caused the delay. He noted the gas detector at the manhole. He cautiously entered holding his breath. His flashlight showed the two men on the floor. He climbed out and sent for a respirator. Both men were dead before they could be removed. It seems the gas main had been purged with nitrogen gas which had escaped into the tunnel when blown out of the pipe. Here is a case where a knowledge of what was going on would have indicated that oxygen content should be tested as well as other toxic gases.

Frequently gas testers have to enter looping pits. These are holes in the ground 80 ft. deep and are used to provide a means of supplying continuous annealing and galvanizing lines with material while one end is stopped to weld on the next coil. Permanent sampling piping is being installed as it is quite a feat to work in them hampered by respirator equipment.

Construction areas frequently require tests to determine carbon monoxide accumulations from trucks, engine driven compressors, heating furnaces and salamanders. Many electrical manholes, pipes, tanks and like enclosures require testing, not only for personnel toxic safety but also for infammable gases and vapours. Any work requiring use of cutting or welding torches on such equipment must be preceded by safety tests. The MSA Explosimeter is the favourite instrument for such tests. It is equipped with means for securing a sample at a safe distance.

Sampling for Combustion Efficiency

In all test sampling of hot gases whether for combustion or air infiltration determinations, it is very necessary to select suitable sampling tube materials.

Steel tubes are not satisfactory when temperature of the gas is above 400 D.F. An Inconel tube is satisfactory for all temperatures below 1000 D.F. For temperatures between 1000 and 2400 D.F. porcelain or fused quartz tubes are used. Above 2400 D.F. one must resort to water cooled probes.

For continuous sampling of hot dusty gases, such as leave an open hearth furnace, special systems have to be used. One of these, designed by the Bailey Meter Company is fully described in their bulletin E65-6.

In all testing pains must be taken to secure a representative sample. This means, that in many cases, considerable study has to be given to the flow pattern of the gases in their enclosure. It is necessary to have the end of the probe in the centre of a fast moving core of gas. Eddies, back flows and openings which could influence the composition of the gaseous mixture must be avoided.

Where a furnace or waste gas flue system is under a slight pressure with respect to atmosphere, selection of a suitable sampling point is greatly simplified.

Quite often sampling points have to be chosen in zones where the pressure is lower than the atmosphere. Great care must be taken in selecting the position and arranging the insertion of the sampling tube. Referring to Fig. 1; arrangement (1) indicates air being infiltrated through the sampling hole and a portion entering the tube. The tube is not only too short but care hasn't been taken to seal the sampling hole with clay. Arrangement (2) indicates a longer tube but the high velocity of the flue gases in a downward direction creates a zone of low pressure on the underside of the tube. Air entering the sampling hole flows along the reduced pressure zone and can enter the end of the tube. Arrangement (3) shows a sampling tube having an arrangement of several sampling holes along its length. It was expected that in this way a representative average sample could be secured. It is a means frequently used to sample waste gas from boilers. Unless it is used with a very powerful aspirator it is useless for such purpose. When used with a hand bulb or a low capacity suction device the greater portion of the sample enters through the hole nearest the exhausting end of the tube. Illustration (4) shows what happens if the sampling tube cannot retain its rigidity due to high temperatures. Tests taken through a tube in this condition can show 100% air. It is a fact that there is a layer of air along the inside of many refractory furnace and duct walls. The arrangement (5) illustrates a water cooled probe. It points out the need to make all joints very tight and avoid pockets which can collect condensed vapours. Drip legs should be provided.

There are other precautions one must take, some of which are almost too obvious to mention. The furnace must be operating in a normal manner. Doors should be all closed and fuel input rates held at the desired point. In cases where gases are being given off from the materials being heated combustion tests should be deferred or special means taken to evaluate. Examples are open hearth furnace and lime kiln.

In general probes should be slanted to place the opening upstream from the sampling hole. This helps reduce the possibility of air being drawn into the entrance.

When measuring the amount of air infiltering into a furnace exhaust duct system, the same precautions mentioned above have to be observed. As most tests require simultaneous sampling uniform procedure is essential. An example of this in the steel industry is in determining the air leakage through all the cleaning and inspection openings at a waste heat boiler.

The chief instruments used to analyse combustion products encountered in a steel plant are the "Heat Prover" and "Fyrite". The orsat has all but disappeared for on-location analysing. Samples of gas prior to entering the Heat Prover are passed through silica jell for drying and horse hair filter to remove dust.

Most furnaces have permanent sampling stations built in at locations chosen from previous studies. Gas flow channels are plotted and confirmed from brick wear patterns. Each year thousands of routine samples are taken for setting combustion efficiency and locating sources of air infiltration. Crews are constantly sealing openings in refractories. Close attention to these items can lead to substantial money savings by reducing fuel and increasing production. Sampling must obviously be consistantly accurate. To insure tight sampling connections frequent tests are made using the familiar under water bubble method.

Sampling for Dust Loading

Some operations in a primary steel plant produce gases containing varying amounts of metallurgical dust. From time to time it is necessary to determine the concentration in a gas stream as well as the physical, chemical and electrical properties of the dust.

Before test locations can be selected certain factors must be carefully reviewed.

Sampling points should be located in a straight duct section with no obstructions in the gas stream for at least the equivalent of eight duct diameters preceding them. Compressed air, water and electrical facilities must be within easy reach. All necessary safety precautions must be taken for sampling personnel.

A testing plan would include the determination of the number of sampling points required to effectively traverse the cross section of the duct. These would vary with the dimensions of the duct, the nature of the gas flow and the distribution of the dust in the duct.

The next step is to determine the velocity pattern of the gas stream at each selected sampling point. This is done using a standard pitot tube. A velocity profile is next prepared for the cross section of the duct. If the flow is variable, as often happens, a velocity profile is prepared for different flows.

The standard method of determining the dust concentration in a gas stream is the probe and filter method. A metered volume of gas is drawn through a filter and the amount of dust deposited on the filter is determined. Dust concentrations are then computed and expressed in unit weight per unit weight of gas.

In sampling the gas an iso-kinetic sampling rate must be maintained. (The velocity through the sampling nozzle must be equal to the prevailing velocity in the gas stream being sampled). If the sampling nozzle velocity is lower than in the duct, collected dust weights will be higher than would have resulted from an iso-kinetic rate. This would produce results indicating higher dust loadings than actually existed. The opposite result is obtained if high nozzle velocities exist. Traverse sampling is necessary when the dust is unevenly distributed throughout the gas stream.

The most common means used to insure iso-kinetic sampling rates is the balanced tube method. This uses the principle that if the velocity through the sampling nozzle is equal to the velocity in the duct the static pressures in both will be equal. Thus if the static pressures in the nozzle and duct are maintained equal iso-kinetic sampling rate will be maintained.

Other precautions that must be observed during sampling are:

1. Carefully check all connections for leaks;
2. Clean probe before and after each test;
3. Allow probe to warm up before commencing to withdraw sample. This is to prevent dust from sticking to condensate on the inside of a cold tube. Point nozzle down stream;
4. Make very sure nozzle is pointing directly into the stream during sampling;
5. Keep the filter above the dew point temperature of the gas. In some cases it may be necessary to electrically heat the filter holder.

Sampling for Temperature Measurements

While the vast majority of temperature measurements are satisfactorily met by the insertion of a thermocouple or radiation station, it is frequently necessary to know the temperature of the gases themselves without having the sensing device influenced by cold and or hot refractories or product being heated.

To accomplish this a special probe is used called a multiple shield high velocity thermocouple. A powerful aspirator is used to withdraw a generous volume of gas from the furnace or flue. This passes over the shielded couple and gives an accurate temperature sensing arrangement. In general, the same rules and precautions used in analyses sampling must be followed for best results.

Sampling for Complete Chemical Analysis

Under this general heading one could list almost every gas encountered in a steel plant. Normally most sampling deals with on-the-spot analyses of one or more gas constituents. Occasionally a complete analysis is required including dew point determinations. These have to be carried out in the laboratory. Examples are fuel and prepared atmosphere gases used for heat treating operations.

For collecting accumulative samples a mercury displacement type of container is recommended. Water is the most convenient medium for displacement sampling, but due to the solubility of carbon dioxide, it should be saturated with gas before use. A salt solution can frequently be used to advantage.

Sample containers — usually glass with seal cocks at each end — can be filled by air or gas displacement. This is essentially a process of sweeping out the original gas content by allowing the sample to stream through the container a sufficient length of time. This is easily done when the gas is under a pressure. A good sample is usually obtained when at least 20 times the sample container volume has passed through.

Once again, all the rules and precautions used in sampling must be followed with special emphasis for gases under less than atmospheric pressure.

Canadian Developments

Kelsey Generating Station Goes On Stream

The Manitoba Hydro-Electric Board's Kelsey Generating Station, the first on the Nelson River, began delivery of power to The International Nickel Company of Canada Limited at Thompson, Manitoba on June 22, 1960. It was a victorious day for engineers and contractors who less than five months before had seen fire levy damages of more than $1 million on this same powerhouse.

Quite a number of steel members have had to be replaced or straightened. The walls and roof are in process of being completely replaced and more than 1000 cu. yds. of concrete have been removed and replaced in the scroll case roof of Unit No. 5.

Work on the Kelsey Generating Station site began in June, 1957 and by the end of June this year two of the five 42,000 H.P. units had been installed. Provision has been made for the addition of a sixth unit.

Convey Speaks on Methods of Reducing Iron Ores

Canada's future will depend to a considerable extent on her iron industry, according to a paper presented by John Convey, Director of the Mines Branch of the Canada Department of Mines and Technical Surveys, Ottawa. Dr. Convey made this remark in a paper delivered at the Conference on "Methods of Reducing Iron Ores" held in Chicago, May 3-5, 1960. Over 50 Canadians were in attendance.

By 1957, he pointed out, Canada's annual iron ore production had increased to ten times the 1949 volume. Since by 1965 it is expected to be in the order of 55,000,000 tons per year, iron ore processing methods are of considerable interest. The blast furnace method of producing iron, Dr. Convey predicts, will continue to be used for the greater part of the iron production in large centres of population and industry. However, in various other parts of the country where the ore is available electric smelting and direct reduction plants will be put into operation.

It is to be noted that although Canada's stores of iron ore are of generous proportions, many parts of Canada are a long distance from any important body of the ore. Likewise, although her coal reserves are more than adequate, much of them lies a long distance from the deposits of iron ore. The opening of the seaway, construction of long-distance pipelines, and the Government's policy of building roads and railways to resources are helping to bridge these gaps.

Athlone Fellowship Recipients Named

Forty Canadian engineers have been awarded Athlone Fellowships by the British Government to study, research, or work in industry in the U.K. during the period 1960-62. They are:

J. A. Abbott, Montreal; E. M. Aziz, London, Ont; H. D. Barber, Saskaoon; P. R. Barnard, Oakville, Ont; T. W. Bremner, Ottawa; D. W. Brown, Victoria; H. F. Button, Regina; S. H. Chisholm, Dorval, Que.; F. A. Christie, Halifax; F. E. Collins, Toronto; T. A. Croil, Edmonton; J. G. Descary, Lachine, Que.; D. Dueck, Toronto; R. M. Duncan, Transcona, Man.; C. Ferland, Drummondville, Que.; R. F. Frindt, Edmonton; T. Garrett, Vancouver; P. M. Gratton, Shefford, Que.; M. Guay, Quebec City; L. P. Haberman, Winnipeg; W. Hanuschak, Transcona, Man.; C. R. Huntley, Vancouver; R. V. L'Archeveque, Montreal; G. M. Lindberg, Edmonton; S. M. Lyle, St. Lambert, Que.; F. W. Maine, Kingston, Ont.; A. A. Marsan, Montreal; J. A. Nilson, Saskatoon; R. B. L. Ross, Toronto; J. P. Y. Rouette, Montreal; R. P. D. Round, Victoria; D. J. Skinner, Halifax; W. D. Smythe, Ottawa; R. J. Taborek, Toronto; A. S. Taylor, Lachute, Que.; G. W. Toop, Vancouver; W. R. Tucker, Montreal; M. A. Ward, Toronto; W. E. Watt, Sudbury, Ont.; C. M. Woodside, Toronto.

Official Opening of the K.W. Neatby Building

A new building dedicated to the memory of the late Dr. Kenneth William

Kelsey Generating Station: (left) view of upstream side of powerhouse during fire, January 30, 1960. (Right) downstream side, showing cofferdam removal and dykes, rockfill dam and sluiceway, June 15, 1960.

Neatby was opened at the Central Experimental Farm, Carling Avenue, Ottawa on June 16, 1960. A commemorative plaque in memory of Dr. Neatby was also unveiled.

Among the distinguished guests at this ceremony was the Minister of Agriculture for Canada, The Honourable Douglas L. Harkness.

Study of Drifting Sand in Lake Ontario Harbours

A group of scientists at Queen's University, Kingston are constructing a model of Cobourg Harbour to scale as part of a more extensive study of drifting sand in Lake Ontario harbours. They have secured a large stone building formerly used as an RCNVR barracks to house their project and have already completed a concrete basin, 51′ x 50′ and 1′ deep. The model harbour, complete with breakwater and other works, will be erected along one side of the basin. On the other side a movable wave-making machine capable of producing waves of different heights and intensities will be constructed. Artificial storms will pound the Cobourg Harbour works from various angles, and the effects of the waves on the sand floor of the harbour will be recorded by various instruments. The principle purpose of the model is to determine what causes navigation channels to become clogged with sand and silt, and what engineers can do about it.

The project is sponsored by the Associate Committee on Waves and Littoral Drift of the National Research Council, Ottawa, in the hope that future harbour works can be designed to decrease or eliminate movement of silt and sand into harbour channels. The work is directed by Professor R. J. Kennedy, Queen's civil engineering professor, and Dr. Arthur Brebner and Dr. B. LeMehaute have charge of particular sections of the program.

Encouragement of Sewage Treatment Plant Installations

The Southern Canada Power Company has recently extended its offer to all municipalities in the service area to pay for the electricity used in the first five years' operation of a sewage treatment plant. In view of the increasing seriousness of the water pollution menace, the company has agreed to supply and pay for the electricity for lighting and the motive force needed to operate a sewage treatment plant for these first five years. The offer is effective until April 1, 1962.

Canadian Institute of Surveying and the International Photogrammetric Congress

The International Society for Photogrammetry is holding its IXth quadrennial congress in September 1960 at London, England, where the latest achievements in aerial surveying and photogrammetric applications in various engineering fields will be discussed. The Canadian Institute of Surveying, one of the most active members of this international photogrammetric association, will be represented at the Congress. Canadian delegates will chair several discussions on the results of international experiments directed from Canada and on important instrumental and theoretical developments. Some recent Canadian achievements are most spectacular and in the opinion of experts will have a great influence on the future development of aerial surveying and mapping methods.

The Canadian Institute of Surveying will be represented by scientists and engineers engaged in photogrammetric work with federal and provincial departments, research agencies, universities, and with commercial photogrammetric companies. An interesting exhibit illustrating the vast application of modern electronic means in Canadian surveying and mapping will be displayed at the Congress. The Canadian Institute of Surveying has also published a special Congress issue of its official journal, The Canadian Surveyor, which describes photogrammetric activities in Canada during the past four years. The contents of this issue will be included in the Archives, the official publication of the International Society for Photogrammetry.

International News

U.S. Breakthrough in Conversion of Nuclear Fission Heat

Scientists at the Westinghouse Testing Reactor, Waltz Mill, Pennsylvania have succeeded in uniting two advanced forms of power generation to convert the heat of fission inside a nuclear reactor directly into electricity. This combination of thermionic and thermoelectric generators in one fuel assembly for insertion in the reactor represents a major step toward using untapped energy inside a reactor.

John W. Simpson, Vice-President and General Manager of the Westinghouse Atomic Power Division, asserts that development work may produce high temperature thermionic-thermoelectric generators for satellite power supplies or other situations where modest amounts of power must be got from light, small equipment. He also suggests that nuclear powered generating stations may in future have three operational stages — thermionic elements to convert the high temperatures in a reactor into electricity, thermoelectric elements to utilize the more moderate temperatures and conventional generating equipment for lower temperatures.

Expansion of Electric Power in Peru and Honduras

On June 29th the World Bank made loans of $24 million and $8.8 million to Peru and Honduras respectively for the development of their electric power supplies. Power in Lima, the administrative, commercial and industrial capital of Peru, will be increased by 70%. Honduras will have its first centralized power system when the 27,000 kw. hydroelectric power plant, provided for by the loan, is completed.

Two separate projects are anticipated in the Lima area. Waters from lakes and rivers on the eastern slopes of the Andes are to be diverted to the Sarnia Eulalia River Basin in the west and a 120,000 kw. power plant will be built at Huinco on the Santa Eulalia.

The power potential of Lake Yojoa and Rio Lindo in Honduras will be developed by construction of dikes, a three-mile canal, an intake structure and penstocks to bring water from the lake to a powerhouse which will be built near the village of Canaveral. The new station is to be installed with two 13,500 kw. generating units and provision for a third. Approximately 175 miles of transmission lines will be built to connect the plant with towns of the northwest.

Sweden Supplies Pulp and Paper Mill Machinery

Rayon silk manufacturers in India have ordered machinery from Sweden for a new mill they are building which will produce 150 tons of bleached pulp per 24 hours. It will be the first rayon pulp mill in the world to use bamboo as raw material. A chip preparation plant is among the units being supplied by Sweden, as well as a cooking plant with compound digestors and a soda recovery boiler.

In Africa a new sulphate mill, based on eucalyptus, with a soda recovery plant is being equipped by Swedish firms. A powerhouse, turbine, two wood-fired steam boilers and a friction debarking plant are on order.

Machinery is also being purchased by Argentina for a rayon sulphite mill, with eucalyptus as raw material, in one area and complete paper factory in another.

UK Industrial Research and Development

The United Kingdom Department of Scientific and Industrial Research has published a report on expenditure by British industry in 1958. It indicates that the U.K. manufacturing industry spent approximately $900 million on research in 1958 compared to some $570 million in 1955. Whereas in 1955 about two-thirds of the research and development expenditure in the manufacturing industry's own establishments was from defence contracts, less than half the expenditure in 1958 was military. Expenditure on non-military research doubled between these years.

Aircraft had the biggest research budget (about $300 million), while electrical engineering spent $192 million and chemicals, $129 million.

(Continued on page 89)

New **Portable Gas Station:** During a recent special demonstration nine F-100 Super Sabres, under test by the Tactical Air Command of the U.S. Air Force, were landed, refueled and ready for flight in less than 30 minutes. The 50,000 gal. station, developed by the Goodyear Tire and Rubber Company and Bowser, Inc., can fuel all types of jet aircraft at a rate of 150-600 gal. per min., servicing as many as six aircraft simultaneously.

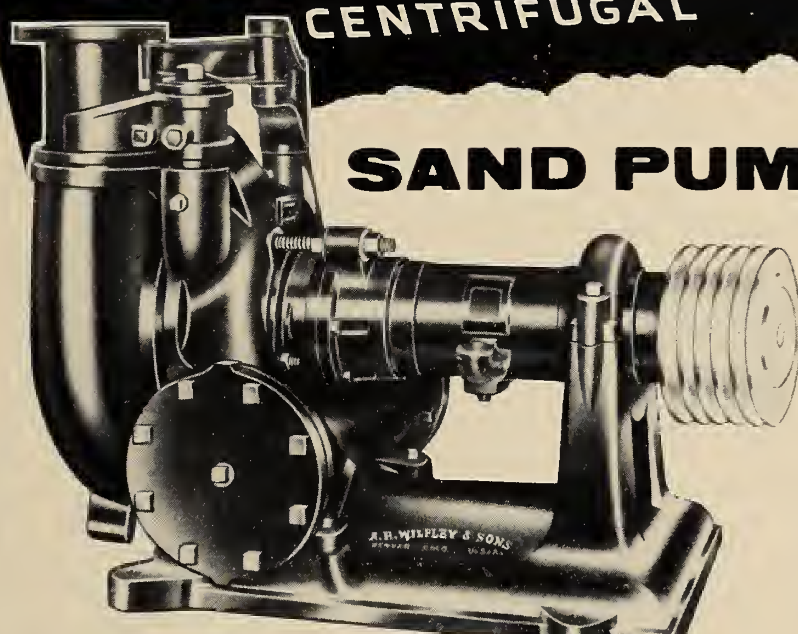
FOR SAND, SLUDGE, SLURRIES, SLIME & ABRASIVES

THE NEW MODEL "K"

WILFLEY

CENTRIFUGAL

SAND PUMPS



For dependable, low cost, trouble free operation and easy maintenance

We manufacture the new high efficiency Wilfley Model K sand pumps in 9 sizes. Capacities range from 20 to 2300 G.P.M., depending on the intake head and density of pulp. **Write for information.**

Improved features of the new Model K include: The remarkable new Wilfley seal — eliminates stuffing box troubles, making the pump especially adaptable to handling gritty pulps, slurries, sludges, hot solutions and eliminates air traps in the runner. Solution slippage is reduced between the runner and follower plate because minimum clearance can be maintained by simple adjustment thereby eliminating over speeding. The four wear parts — case, runner, die ring and follower plate can be changed in minutes without disturbing intake or discharge pipe, saving valuable time. Rubber covered, Ni-Hard and special acid resisting alloy wear parts can be furnished when required.

MANITOBA BRIDGE

AND ENGINEERING WORKS LIMITED

WINNIPEG MANITOBA

MB 8-3

Month to Month

Employment and Earnings, 1959

The Economics and Research Branch of the Department of Labour has compiled comprehensive statistics and analyses of Canada's manpower resources in the scientific and technical professions during 1959. Results of their survey show that median earnings were $7,900. Twenty-five percent of those surveyed were earning less than $6,400 and 25% were earning more than $10,100. The median was highest for architects, followed by engineers, among the five major professions tabulated on the basis of academic specialization.

TABLE I

Quartile and Median Earnings, 1959

Scientific and Technical Professions

*Specialization**	*First Quartile*	*Median*	*Third Quartile*
	$	$	$
Agriculture	5,400	6,450	7,750
Architecture	6,300	8,750	13,950
Engineering	6,800	8,300	10,550
Natural Science	6,150	7,600	9,500
Veterinary Science	6,200	7,350	8,800
TOTAL	6,400	7,900	10,100

*The academic specializations shown in this report are based on undergraduate courses. Forestry and mathematics are included under the heading "natural science" for the purposes of this report.

Regionally, earnings for those employed in Canada were highest in Ontario and Quebec. Canadian citizens working in other countries were also included in this survey, but the respondents from the U.S. were an older group than those in Canada and this is reflected in the higher median earnings for the U.S.

TABLE II

Median Earnings by Specialization and Place of Employment, 1959*

Scientific and Technical Professions

	Place of Employment						
Specialization	*Canada*	*Atlantic*	*Quebec*	*Ontario*	*Prairies*	*B.C.*	*U.S.*
	$	$	$	$	$	$	$
Agriculture	6,450	5,700	5,850	6,900	6,500	6,200	—
Architecture	8,850	—	9,150	9,200	8,350	8,050	—
Engineering	8,250	7,400	8,500	8,300	7,900	8,250	9,600
Natural Science	7,450	6,550	7,600	8,000	7,300	6,950	9,300
Veterinary Science	7,350	—	6,500	7,550	7,750	—	—
TOTAL	7,850	6,900	7,900	8,050	7,450	7,650	—

*Dashes are shown where there were insufficient data to compute medians.

Luncheon for Norman G. Allen

Mr. H. Norman G. Allen, Vice-President of the Institution of Mechanical Engineers of Great Britain, was guest of honour at a luncheon given by The Institute at the Engineers Club, Montreal, on June 17, before returning to London. Mr. Allen was in Canada to attend the E.I.C. Annual General Meeting.

The luncheon was presided over by the President, George McKinstry Dick, M.E.I.C., who took the opportunity, on behalf of the Institute and the assembled group, to thank Mr. Allen for his kindness in coming to Canada at this time. The guests included: Hugh G. Conn, M.E.I.C.; A. Robert Edis, M.E.I.C.; W. P. Ferguson, M.E.I.C.; Henri Gaudefroy, M.E.I.C.; William Milne, M.E.I.C.; D. Gray-Donald, M.E.I.C.; S. Howe; J. R. Y. Johnston; E. B. Jubien, M.E.I.C.; T. R. McLagen, M.E.I.C.; Donald L. Mordell, M.E.I.C.; W. J. Paton; P. W. Gooch, M.E.I.C.; Harold Hurdle, M.E.I.C.; H. Ulman, M.E.I.C.; J. A. Watson; D. L. Spanjer, M.E.I.C. Garnet T. Page and George M. Dick were hosts.

CTF Mathematics Seminar

The professions which make day-to-day use of mathematics could contribute significantly to better curriculum planning for the schools. This was the sentiment brought forth in the early-summer CTF Seminar on "New Thinking in School Mathematics", held at the Chateau Laurier, Ottawa.

An informal survey made by the CTF in advance of the seminar indicated that in many parts of Canada highly trained mathematics teachers are not available. It also showed that the requirements for mathematics teaching are not generally high. Neither is the student of high mathematical ability provided for by present school curricula. The seminar made clear that where curriculum planning was possible on a provincial level, with representation from the department of education, teachers, university faculty, educational psychologists and professionals using mathematics, the results were good.

Professor J. E. Ruptash, Director of Engineering School, Carleton University, Ottawa, represented the Institute at the seminar.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and transfers were effected at a meeting of council on May 24, 1960.

Member: E. P. Boddaert, Montreal; D. B. Chamney, Calgary; F. S. Clark, Toronto; N. Devich, Iroquois Falls; J. J. Fedy, Kitchener; J. A. G. Hunter, Montreal; J. E. Hutton, Calgary; B. H. Lloyd, Montreal; J. R. McEachern, Sarnia; J. H. McGuire, Ottawa; M. J. Salm, Edmonton; J. L. Seychuk, Toronto; J. L. Simard, Montreal; W. P. Steele, Vancouver; E. J. Wiggans, Arvida.

Junior: P. F. Bacave, Montreal; A. C. Kanen, Welland; F. J. Mayer, Hamilton; D. V. Sedlak, Montreal; C. Soydemir, Boston, Mass.

Junior to Member: D. L. Aker, Arvida; G. T. Alexander, Montreal; A. J. Arcand, Camp Valcartier; A. F. Avant, Toronto; S. J. Babin, N. Weymouth, Mass.; A. H. Baker, North Bay; W. K. Baldwin, Sherbrooke; W. R. Ball, Toronto; R. G. Barbour, Granby; E. A. Beaumont, Prince George; A. P. V. Bennett, Montreal; J. M. Bentham, Montreal; J. M. Bird, Vancouver; R. A. Blount, Montreal; M. G. Bolstad, Caledonia; J. D. Booth, Montreal; D. T. Bourke, Montreal; K. B. Bourne, Brownsburg; P. R. Brais, Arvida; N. B. Breen, Kingston; T. E. Buck, Don Mills; R. F. Cairns, Toronto; D. S. Cameron, Montreal; E. G. Capling, Calgary; J. E. Cash, St. Catharines; S. Cherry, Vancouver; W. I. W. E. Christmas, Montreal; J. L. Clark, San Francisco; L. W. Clark, Ottawa; R. H. Clawson, Halifax; J. Corey, Montreal; J. P. R. Cristel, Montreal; G. V. D. Crombie, Toronto; G. H. Curtis, Toronto; C. V. Davies, Walkerville; R. I. Davis, Peterborough; J. T. Denley, Campbell River, B.C.; W. J. Dickson, Camp Valcartier; T. T. Dobie, Trail; J. Dubuc, Montreal; G. Ducharme, Montreal; P. T. Duff, Toronto; E. W. Dunlap, Guelph; J. J. Eatock, Edmonton; C. R. Eaton, Peterborough; W. J. Eden, Ottawa; J. A. Eddleston, Vancouver; D. W. Ellis, Sarnia; G. E. Estey, Otter Rapids; E. R. Evans, Burlington, Ont.; W. L. J. Fallow, Calgary; D. U. Findlay, Brownsburg; A. D. Finlayson, Copper Cliff; B. H. Fleming, Vancouver; C. G. Forberg, London; C. D. Forbes, Vancouver; J. Forte, Montreal; G. Fournier, Acton Vale; F. H. Frappier, Ottawa; A. Ganton, Niagara Falls; R. I. Gilchrist, Montreal; H. F. Godin, Montreal; K. P. Gould, Montreal; J. A. Gurnham, Preston; H. M. Hadley, Montreal; D. J. Hains, Toronto; R. Haliburton, Deep River; J. M. Hall, Toronto; T. P. Halley, Port Cartier; P. N. Hanson, Grand'Mere; D. M. Harris, Owen Sound; E. W. Hayes, Kitchener; H. V. Henderson, Toronto; A. D. Heron, Montreal; E. T. Hilbig, Belleville; R. C. Hodge, Smooth Rock Falls; S. A. Hudson, Toronto; J. G. Irving, Bridgewater; G. P. Kemp, Toronto; R. E. Keyes, Calgary; W. R. Kinnear, Toronto; A. Kriger, Ottawa; J. J. Larocque, Montreal; H. K. Larsen, St. John, N.B.; F. J. Le Blanc, Montreal; H. J. H. A. Lee, Guelph; J. M. Leger, Montreal; W. F. Light, Montreal; R. H. Little, Montreal; C. C. Louttit, Arvida; E. A. A. Love, Shawinigan; G. O. Lucas, Edmonton; R. W. Ly, Peterborough; C. H. Maartman, Vancouver; K. C. Mackenzie, Ottawa; L. S. Maclure, Niagara Falls; N. McCarthy, Hamilton; A. D. McCutcheon, Spragge, Ont.; J. B. McLaren, Vancouver; J. M. McLaughlin, Sarnia; J. W. McNaughton, Montreal; F. R. Mehling, Vancouver; E. L. Mercer, Toronto; F. S. Miller, Montreal; J. G. Mitchell, Hamilton; C. W. Morgan, Windsor; M. Murchison, Montreal; M. P. Murphy, Montreal; J. S. Mutchmor, Arvida; F. W. New, Winnipeg; R. C. Newman, Dundas; B. L. Nugent, Edmonton; E. E. Paine, Arvida; E. G. Parker, Vancouver; W. A. D. Parratt, Toronto; W. F. Patterson, Montreal; L. A. Pattison, Three Rivers; G. K. F. Pepper, Toronto; C. H. Perreault, Kenogami; G. H. Perron, Chicoutimi; J. E. Pescod, Cornwall; A. B. Platt, Sudbury; W. H. Potts, Toronto; S. R. Price, Niagara Falls; R. Proudfoot, Windsor; L. Putsep, Montreal; G. A. Read, Montreal; J. Renchko, Niagara Falls; A. G. Ringuette, Granby; A. E. Risk, Montreal; G. C. Ritcey, Pembroke; I. C. Rogers, Toronto; R. J. Ross, Toronto; W. G. Rowan, Montreal; M. L. Rush, Taylor; A. Ryttel, Montreal; J. R. Sabourin, Montreal; E. C. Scott, Montreal; K. W. Short, Willowdale; N. D. Simmons, Hamilton; J. T. Sinclair, Sarnia; G. L. Smith, Saint John, N.B.; A. E. Speers, Toronto; J. A. Spinney, Copper Cliff; K. W. Stairs, Ottawa; H. A. Stevenson, Vancouver; W. L. Stewart, Montreal; A. R. Stienstra, Hamilton; J. G. Sutherland, Kingston; E. G. F. Sweet, Brantford; R. B. Sweet, Windsor Mills; P. J. Tansey, Montreal; J. S. Taylor, Beauharnois; D. S. Templeton, St. John's, Nfld.; J. Thibaudeau, Montreal; D. L. Townsend, Kingston; N. G. Trower, Oromocto, N.B.; H. J. Tucker, Montreal; A. G. Turton, Ottawa; R. G. Urquhart, Castlegar, B.C.; J. van Beck, Cornwall; J. Veilleux, Quebec; G. S. Warner, Montreal; L. J. Westwood, Toronto; H. M. Whittles, Sudbury; J. E. Wilson, Toronto; R. E. Winter, Toronto; D. M. Wishart, Edmonton; W. R. M. Wood, Montreal; L. H. Yeomans, Toronto; H. N. Young, Thetford Mines.

Student to Junior: M. J. Heuer, Toronto; A. M. McMahon, North Bay; J. M. R. Thomson, Montreal; D. R. Turnbull, London.

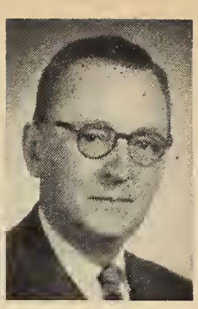
STUDENTS ADMITTED

University of Waterloo: J. D. Balfour, C. G. Edgar, S. Ferrero, R. S. Goodall, R.

(Continued on page 89)

The DUGGAN MEDAL and PRIZE

was awarded by the Institute to A. G. Davenport, JR.E.I.C., now at the University of Bristol, England. It was presented to him last month at the Institution of Electrical Engineers in London by Mr. F. L. Lawton, Vice-President, Montreal.



President's Column

IMMEDIATELY following his return from Winnipeg, your President started off his time honoured duties by visiting, with his wife, his home Branch, the Eastern Townships Branch, where the Chairman, James Davidson, presided at their Annual meeting and Ladies' Night at Hovey Manor, North Hatley, Quebec. A good attendance of members and their wives from Sherbrooke and district, together with a fine respresentation from Montreal, permitted the new President to extend his personal thanks to the Branch for their part in the Presidential nomination. During his initial speech the President emphasized the important part which the Canadian Engineer must take in the future development of this country, and made a plea for continued technical growth of each engineer by extended interest in such spheres over and beyond the normal composite of his regular duties.

Presidential visits to Branches will commence in early September, with attendance at the Maritime Professional Engineers' Conference at St. Andrews, New Brunswick, where your President will be the guest speaker at one of the principal events. Visits to the Newfoundland Branches will follow.

Summer activities at the Engineering Institute include studies by a special Committee of the membership structure, and procedures, of the Engineering Institute. It is hoped that we can find methods of handling membership activities which will improve member relationships with the Institute.

The Engineering Council for Professional Development, of which E.I.C. is a member, is holding its Annual Meeting in Montreal on October 3rd and 4th. It is expected that a wide representation of interested Engineers from both United States and Canada will be present.

Joint meetings of ASME-EIC on Engineering education, scheduled to be held at Ecole Polytechnique, October 5th and 6th, under the guidance of a Committee under Dean Mordell of McGill University, should prove interesting and of considerable value in analyzing Engineering education requirements and what steps are necessary to improve this important feature.

The first of the newly authorized Executive Committee meetings will be held in Montreal, July 22nd. This new departure is a novel development in E. I. C. administration and will be watched with interest both by Council and the membership at large.

H. HAWRYLUK

THE Cook at Crane

FOLLOWS HIS RECIPES CAREFULLY

The ingredients for Crane valve metal are scientifically specified — so much pig iron, so much scrap iron, so much limestone and other materials. Harry Hawryluk weighs these ingredients carefully to make sure that the correct charges go to the cupolas for "cooking". His work is vital to valve quality — the care he takes is typical at Crane.

1 out of every 12 employees at Crane's Montreal plant is a tester or inspector. They test raw materials — metals, sand — continuously...they subject finished valves to tests 2½ to 3 times as severe as they'll meet in normal service. The PAINS they take form one of the reasons why a Crane valve is the best buy in the long run.

Another reason: PEOPLE. The Crane technical people (at your service anywhere in Canada) have heard just about everything there is to hear about valves. They can give you PRACTICAL advice on valve selection, use and maintenance — whatever your business. Crane Head Office: 1170 Beaver Hall Square, Montreal.

SUCCESS STORY: CRANE VALVE STILL SERVES AFTER 70 YEARS!

Recently — in the course of routine maintenance at the Petrolia, Ontario, Waterworks — a trench was dug. It uncovered a 12″ Crane waterworks valve that had been installed in 1890. We can't show you a picture of the actual valve because the investigators found that it was still doing its job perfectly so they simply covered it up again. Crane care makes today's valves just as reliable.

CRANE VALVES • PIPING • PLUMBING • HEATING • AIR-CONDITIONING

F. Isaac, H. R. Krzywicki, R. J. Mitchell, J. W. Olan, R. W. Schellenberg, R. A. Stoltz, R. A. Tompkins, C. Wood.

St. Francis Xavier University: R. N. Cloutier, J. P. J. Deschenes, J. B. Lafortune, C. G. Robichaud, J. P. Sokolyk, L. G. Veilleux.

Nova Scotia Technical College: D. L. Conrad, J. M. McNally, R. J. R. Weld.

McMaster University: D. Anbrett, K. G. Pollock.

McGill University: A. R. Campbell.

Queen's University: D. H. Smith.

University of Toronto: L. A. Bednarz.

Lakehead College: A. Grootenboer.

College Militaire Royal de St. Jean: J. R. F. M. Turgeon.

University of Detroit: J. M. Wagner, Karl Lapins, B.Sc. (Mining) Queen's 1959.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers have become effective.

ALBERTA

Member: R. A. S. Brown.

Junior to Member: G. F. Coates, F. R. Dorward, R. O. Jonasson, T. Kostiuk, E. F. Provost, A. L. Whitehead.

SASKATCHEWAN

Member: H. Carswell, O. P. Lesiuk, C. G. D. Poland, J. H. Speer, J. N. Stephenson.

Junior: D. R. Foulger, A. Lissey, W. D. MacKay, R. Warchola.

Junior to Member: G. E. Cummings, H. R. Daniel.

Student to Junior: L. E. Stanley, B. J. Stolee.

Students: D. W. Cheney, A. Lipton, W. Nepip, J. M. Shea, J. G. Verhoeven.

NEW BRUNSWICK

Member: A. Douma.

Junior to Member: H. M. James.

MANITOBA

Junior to Member: J. L. Pulford.

• INTERNATIONAL NEWS

(Continued from page 82)

New European Federation on Corrosion

Fifty scientific and engineering associations have joined in a European Federation on Corrosion which held its first symposium in Frankfurt recently. Cathodic protection from corrosion was the subject of discussion, including the most recent German research on electric anti-corrosion measures.

Dr. E. Eberius, of Duisburg, explained that it has long been known that iron is corroded by the formation of tiny electric elements on its surface. Corrosion consists of an exodus of iron ions. The traditional method of making an iron surface into a cathode by applying a baser metal such as zinc or magnesium is being replaced in some instances now by connecting the iron to the negative pole of a source of direct current.

The German Federal Republic, said Dr. Eberius, has some 2000 miles of pipelines protected cathodically at present, including the water supply line from Lake Constance to Stuttgart.

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Official Registered Attendance at the 74th Annual General Meeting Winnipeg 1960

75th

Annual General and Professional Meeting

Vancouver May 31 - June 2 1961

SIR CASIMIR STANISLAUS GZOWSKI

a biography

by Ludwick Kos-Rabcewicz-Zubkowski, L.L.D.

and

William Edward Greening, M.A.

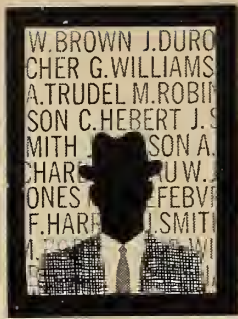
(Published under the auspices of the Engineering Institute of Canada)

This volume may be ordered from the E.I.C. Library.

When ordered for a member of the Institute the regular retail price of $4.75 is reduced to $3.80.

The volume describes the background and achievements of one of Canada's outstanding engineers.

Personals



Geoffrey A. Gaherty, M.E.I.C. (Dalhousie '09), President of the Montreal Engineering Company and a director of Atomic Energy of Canada Ltd., was awarded an honorary Doctor of Engineering degree at the N.S.T.C. convocation.

T. R. McLagan, M.E.I.C. (McGill '23), President and General Manager of Canada Steamship Lines Ltd., Montreal, was recently elected 1960-61 President of the Canadian Manufacturers' Association.

Charles H. Pigot, M.E.I.C. (McGill '26) has been appointed Assistant Chief Engineer of the Power Development Division of Hydro-Quebec.

The following are to be recipients of Canadian Good Roads Association fellowships: **Paul-Henri Durand**, JR.E.I.C. (Laval '58), of the Quebec Department of Roads, to study at Purdue University; **K. G. C. Smith**, JR.E.I.C. (Toronto '53), of Proctor & Redfern, Toronto, to study at the University of California; **J. A. Knowles**, S.E.I.C. (Manitoba '60) to study at the University of Alberta; and **Y. I. Fellman**, JR.E.I.C. (Queen's University, Belfast '56), of the Newfoundland Department of Highways, to study at Queen's University.

P. H. Durand, JR.E.I.C.

K. G. C. Smith, JR.E.I.C.

F. Russell Stone, M.E.I.C. (Toronto '30) has been appointed District Representative in Eastern Canada for North American Refractories Ltd., to be located in Montreal.

C. B. Jackson, M.E.I.C. (Saskatchewan '31) has been appointed Vice-President of Alchem Ltd., Burlington, Ont.

Austin D. Misener, M.E.I.C. (Toronto '33) has been appointed F.R.S.C. Director of the Ontario Research Foundation. Since 1949 Mr. Misener has headed the Department of Physics at the University of Western Ontario.

Mortimer A. Montgomery, M.E.I.C. (Saskatchewan '34) has been elected Vice-President of Sales for The Canadian Blower & Forge Company Ltd., Kitchener, Ont.

E. L. Neal, M.E.I.C. (Queen's '38) has been elected a director of Anglo-Newfoundland Development Company Ltd. He is President and General Manager of Gaspesia Sulphite Company Ltd. of which he is also a member of the board.

J. A. Knowles, S.E.I.C.

Y. I. Fellman, JR.E.I.C.

H. P. Hershman, M.E.I.C. (McGill '45), formerly of J. Becker Inc., has opened his own air-conditioning business, Airco Installations Ltd., and is acting as its President.

J. Terence Gregg, M.E.I.C. (Queen's University, Belfast '49) has been appointed Chief Engineer and a director of Morrison, Hershfield, Millman and Huggins, Ltd., Consulting Engineers, Toronto. For the past six years he has been Supervising Bridge Engineer for the Foundation Engineering Corporation Ltd.

W. H. Nord, M.E.I.C. (Toronto '48) has been made Plant Manager of the Northern Pigment Company Ltd., New Toronto, Ont.

A. Ray Dow, M.E.I.C. (Toronto '49) has been named General Sales Manager of British Oxygen Canada Ltd.

F. M. McGuire, JR.E.I.C. (U.N.B. '50) has been appointed Manager of Dominion Structural Steel Company's operations in the Winnipeg-St. Boniface area.

W. P. London, M.E.I.C.

W. P. London, M.E.I.C. (New Brunswick '34), formerly Chief Engineer, Thermal Division, H. G. Acres & Company Ltd., announces the formation of the firm of W. P. London and Partners, Consulting Engineers, Niagara Falls, Ontario. A complete range of engineering services in the mechanical, civil, and electrical fields is offered by the firm.

P. A. Pasquet, M.E.I.C. (Queen's '42), A. C. Shamess, M.E.I.C. (Toronto '46), and **Harold Jones**, M.E.I.C. (Manchester College of Technology '33), all formerly with H. G. Acres & Company Ltd., have joined the firm of W. P. London and Partners, Consulting Engineers, Niagara Falls, Ontario, as partners.

Donald Robson, M.E.I.C. (N.S.T.C. '50) has recently joined the staff of the National Research Council, Division of Building Research, as a member of its Atlantic Regional Station in Halifax.

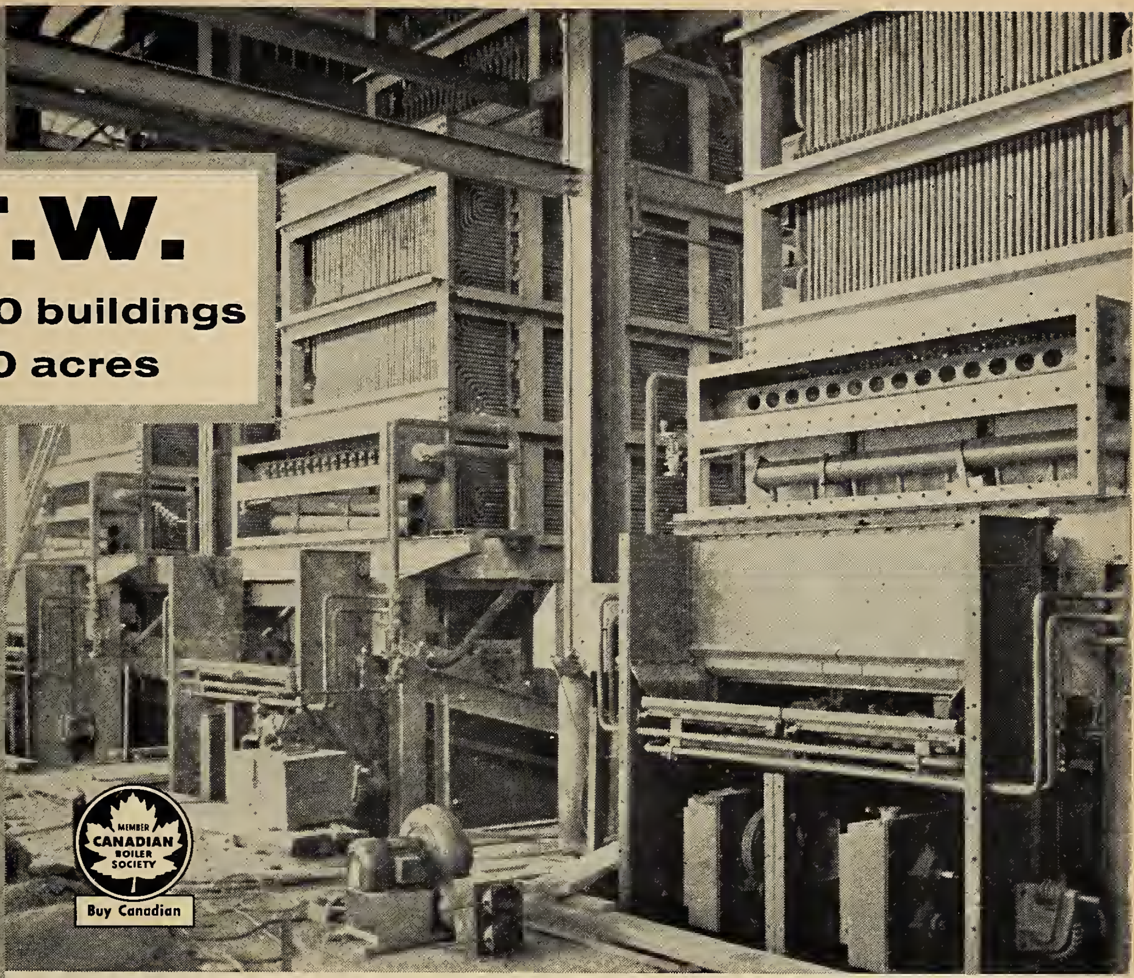
A. E. Insley, JR.E.I.C. (U.B.C. '53) has been named Soils Engineer with R. C. Thurber and Associates, consulting civil engineers, Victoria, B.C.

Lester L. Atkinson, JR.E.I.C. (N.S.T.C. '53), of Kingsport, N.S., has been appointed the first Analytical Services Officer of Canadian National Railways Atlantic Region, with headquarters in Moncton.

Karl Van Dalen, JR.E.I.C. (Queen's '57) has returned to Canada after two years at Imperial College of Science and Technology, London, on an Athlone Fellowship. He will take up duties as a lecturer in civil engineering at Carleton University, Ottawa.

H.T.W.

heats 20 buildings on 1,200 acres



At the Central Experimental Farm Ottawa three Dominion Bridge 30,000,000 btu *high temperature water* boilers have been installed to satisfy the varied heating requirements of twenty buildings spread over some 1,200 acres. The installation provides for space heating and domestic hot water, and low pressure steam for a large number of special applications such as air-conditioning, autoclaves, sterilizers, pressure cookers, laboratory outlets, etc.

Each boiler is equipped with a fully water-cooled Vibra-grate stoker designed to burn Canadian bituminous coal and provision is made for alternative oil firing. The system is pressurized by nitrogen in an expansion tank and the water temperature is maintained at 366°F.

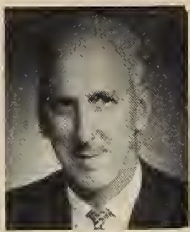
In applications of this kind, where heat must be distributed over a wide area, H.T.W. offers very definite advantages. These are evident in lower overall costs due largely to the absence of corrosion, the elimination of condensate traps and separators, and the fact that mains pipes may be laid without regard for levels or grades. Because of the high thermal storage of the system a smaller capacity plant is possible, an advantage that reduces fluctuation in the firing rate to give better overall efficiency. Capital costs are comparable with H.P.S. installations.

Dominion Bridge designs and manufactures watertube and firetube boilers for a wide variety of applications. A call to the Boiler Products Division at any of its offices across the country will put their long experience at your service.

49

Boiler Products Division **DOMINION BRIDGE**

DOMINION BRIDGE COMPANY LIMITED - FIFTEEN PLANTS COAST-TO-COAST



C. A. Peachey, M.E.I.C.

C. A. Peachey, M.E.I.C. (Toronto '27), General Manager of the Communications Equipment Division, Northern Electric Company Ltd., has been appointed to the Defence Research Board.

L. Donald Sanderson, S.E.I.C. (Manitoba '60) has begun work as a mechanical engineer with the Aluminum Company of Canada at the Arvida works.

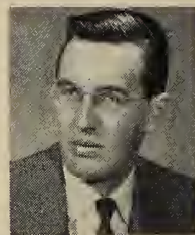
William J. Gibson, S.E.I.C. (N.S.T.C. '60) has accepted a position with the Aluminum Company of Canada as process engineer at the Arvida works.

A. C. Ridgers, M.E.I.C. has been appointed Assistant to the Manager of the Engineering Division of The Consolidated Mining and Smelting Company, Trail, B.C.

Edward A. Silver S.E.I.C. (McGill '59) is working toward an M.Sc. in Operations Research at the Massachusetts Institute of Technology.

E. H. Martin, M.E.I.C.

Eric H. Martin, M.E.I.C. (Manitoba '47) has been appointed to head the construction division of the British Columbia Power Commission.



H. J. T. Patterson, M.E.I.C.

H. J. T. Patterson, M.E.I.C. (McGill '48) has been appointed District Sales Manager for Dominion Structural Steel Ltd., Montreal.

Ken W. Short, JR.E.I.C. (Toronto '48) has formed a new partnership for the practice of engineering and architecture in Willowdale, Ontario, which is to be known as Ball, Craig, Short & Strong, engineers and architect.

John T. Dyment, M.E.I.C. (Toronto '29), Chief Engineer for Trans-Canada Air Lines, has been elected to the board of directors of the Society of Automotive Engineers.

A. G. Murphy, M.E.I.C.

A. Gordon Murphy, M.E.I.C. (McGill '22), Chief Engineer for The St. Lawrence Seaway Authority, had an honorary degree of Doctor of Laws bestowed upon him at the McGill University spring convocation.

James Douglas Robertson, M.E.I.C. (Manitoba '45) is Head of Electrical Engineering with I.O.R.C. in South Iran.

Clarence A. Parker, S.E.I.C. (N.S.T.C. '60) has taken up a position as process engineer at the Arvida works of the Aluminum Company of Canada.

(more Personals on page 125)

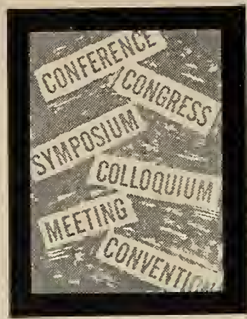
(Continued from page 76)

the rule of thumb can be safely used, especially where relatively massive and other than horizontally stratified rock was involved.

The authors mention that, as a result of comparison between water test data and grout acceptance, a mix of one part of cement to six parts of water was found suitable for sealing the fine seams in the bed rock. It would be interesting to know whether co-efficients of "secondary" permeability, K, for the rock were computed from the results of the water testing, and if there was any correlation between such coefficients and grout acceptance. It is recognized that with so many variables involved, a simple correlation between secondary permeability and grout acceptance would probably not be possible, but at least such studies may have yielded information as to the lower limit of the co-efficient of secondary permeability at which acceptance of grout will take place. It has been suggested that this lower limit is represented by a K value for the rock of 10^{-4} cms. per second, although based on a limited number of tests our experience would indicate that the lower limit of K is even less than this. (The co-efficients in the tests mentioned being computed from pressure pumping test data using methods outlined in the U.S. Department of the Interior, Bureau of Reclamation, "Earch Manual"). In this connection it is worth noting that research carried out by the U.S. Corps of Engineers has apparently shown that it is doubtful whether grouting would be at all effective in any fissures which are smaller than 3 times the maximum particle size in the cement. It would be interesting to know also, if the results of other work on this project, such as an examination of rock cores taken after grouting, confirmed the above criterion.

The data on the actual acceptance of grout per foot of hole in order to give a water-tight foundation in this case is useful information. Merely by way of comparison, it may be worth adding that published precedent and our experience elsewhere in foundation rock consisting of sandstones and limestones indicates that acceptances of between 0.05 and about 2.0 bags of cement per foot of hole can be expected. In one case involving sandstone rock acceptances of 0.06 to 0.30 bags per foot of hole were obtained, while to consolidate a limestone and shale foundation in another instance between about 0.5 to 1.0 bags of cement per foot of hole were required. In both of the above-mentioned examples, the grout acceptance at various locations on the site varied considerably, and this, according to published data, seems to be often the case. The variation seemed to be greater than was apparently experienced on the project discussed in the paper. The generally low average acceptance of the grout and the general uniformity of the foundation rock across the site as indicated by the grout acceptance results, point to a good final choice of site from the point of view of foundations.

Other Societies



1960 Canadian Trade Fairs

The Foreign Trade Service of the Canadian Department of Trade and Commerce has published a schedule of Canadian Trade Fairs for the remainder of 1960. Among the 70 trade fairs to be held in many different parts of the country are: 3rd Canadian National Material Handling Show and Conference, Montreal, September 26-30; Montreal International Trade Fair, October 25-November 6; Canada's Great Eastern Exhibition, Sherbrooke, August 26-September 1; Canadian National Exhibition, Toronto, August 24-September 10; Pacific National Exhibition, Vancouver, August 20-September 5.

Canadian Copper and Brass Association

A new quarterly bulletin "Canadian Copper & Brass" is being published in February, May, September, and November, to give up-to-date information on copper, copper alloys and copper compounds. It can be obtained free by contacting the Association, Room 1101, 55 Yonge Street, Toronto 1. The Association has also published its first book, entitled "Copper in Canada".

International Society of Soil Mechanics and Foundation Engineering

The proceedings of the First Asian Regional Conference of the International Society of Soil Mechanics and Foundation Engineering, arranged by the Indian National Society of Soil Mechanics and Foundation Engineering and held at New Delhi, February 4-7, 1960, are being published. The volume will be ready by Fall and can be ordered from the Indian Society, c/o Central Board of Irrigation and Power, Curzon Road, New Delhi 1, for $11.

Attending the conference were scientists and engineers from India, Israel, Japan and the U.S.S.R. The construction and behaviour of earthen embankments, the foundations of structures other than hydraulic structures, general soil stabilization techniques and field measurement and sampling were discussed.

American Welding Society

Recommended Practices for Metallizing Shafts or Similar Objects, a publication of the American Welding Society, has been revised, introducing a new section on surface preparation for metallizing. The 32-page booklet is available for $1 from the American Welding Society, Dept. T, 33 West 39th Street, New York 18, N.Y.

The Society of Naval Architects and Marine Engineers

Four graduate scholarships for the coming academic year have been awarded by The Society of Naval Architects and Marine Engineers, New York. The two recipients of awards for marine engineering study are George Webb, to study at the Virginia Polytechnic Institute and Roy L. Harrington, to study at the University of Michigan. All four scholarships are for two semesters' tuition and living expenses.

Industrial Education Institute

Among the summer and fall seminars scheduled by the Industrial Education Institute, Boston, are: "More Effective Problem Solving in Engineering, Manufacturing and Marketing", August 15; "Measuring and Improving the Effectiveness of the Maintenance Department", August 30; "Inventory Control", September 22: "Calculating the Return on Proposed Projects, Equipment or Plant Facilities", all to be held at the Sheraton-Mt. Royal Hotel, Montreal.

American Welding Society Bibliographies

The AWS has announced the availability of the 1959 supplement to the AWS Bibliographies. The original publication contained bibliographies of articles which appeared in the Welding Journal from 1937 through 1957, and each year a supplement is compiled listing the previous year's articles. Copies may be obtained from the American Welding Society, Department T., 33 West 39th Street, New York 18, N.Y. The cost is $1.50.

Water Pollution Control Federation

"Design and Construction of Sanitary and Storm Sewers," the Water Pollution Control Federation's latest edition to its Manual of Practice Series, is now available. Popularly known as "The Sewer Manual", this publication is the result of several years' joint effort by the Federation and the American Society of

(Continued on page 101)

The Associations and Corporation

The April Issue of *The Professional Engineer*, the Journal of the Association of Professional Engineers of Ontario, listed a number of correspondence courses which would be available to members if enough interest were shown. Returns from the questionnaire on this subject have indicated that courses in Advanced Mathematics and Engineering Computer Programming are most sought after. The current issue of *The Professional Engineer* lists the courses to be offered and required tests and registration forms. The Ontario Professional Engineers Foundation has agreed to underwrite losses up to $500 for the course in Engineer Computer Programming which is expensive both to prepare and to operate. Exercises submitted by students will be put through the computers at the University of Toronto and incorrect solutions will probably be returned to students for correction, then put through the computers a second time.

The original date of the Annual Convention of the Municipal Engineers' Division of the Association of Professional Engineers of B.C. has been changed to September 22-24. It is to be held, as planned, at Trail, B.C. Among the papers to be delivered are: "Street Markings and Signs", J. H. Harding, B.C. Department of Highways; "Chemical Aids to Municipal Engineers", F. J. L. Miller, Cominco; "Smoke Control", J. F. Snowball, Cominco; "Urban Redevelopment", H. Peter Oberlander, U.B.C.; "Asphalt", N. M. McCallum, Willis & Cunliffe Engineering Ltd., Victoria.

● OTHER SOCIETIES

(Continued from page 98)

Civil Engineers. Orders should be placed with the Water Pollution Control Federation 4435 Wisconsin Avenue, N.W., Washington 16, D.C.

Coming Events:

A Symposium on "Stereochemistry in Organic Reactions", University of Alberta, Edmonton — September 6-7.

Symposium on Fundamental Aspects of Atomic Reactions (The Chemical Institute of Canada), McGill University, Montreal — September 6-7.

Symposium on Nuclear and Radio-Chemistry (The Chemical Institute of Canada and AECL), Chalk River, Ont. — September 6-8.

1st Joint Automatic Control Conference (ISA, AIChE, AIEE, ASME, IRE), M.I.T., Cambridge, Mass. — September 7-9.

ISA Fall Instrumentation-Automation Conference & Exhibit and ISA Annual Meeting, New York Colliseum, N.Y. — September 26-30.

13th Annual Conference on Electrical Techniques in Medicine and Biology (ISA, AIEE, IRE), Sheraton Park Hotel, Washington, D.C. — October 31-November 2.

Coal Meeting (Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers), Chase Park Plaza Hotel, St. Louis, Mo. — September 8-9.

4th Annual Joint Military-Industrial Electronic Test Equipment Symposium (Office of the Director of Defense Research and Engineering and the Department of the Army Signal Corps), Museum of Science and Industry, Illinois Institute of Technology, Chicago — September 14-15.

8th Annual Engineering Management Conference, Chicago — September 15-16.

4th International Industrial & Technical Exhibition, Charleroi, Belgium — September 15-26.

Symposium on the Numerical Treatment of Ordinary Differential, Integral and Integro-Differential Equations (International Computation Centre, Rome), University of Rome—September 20-24.

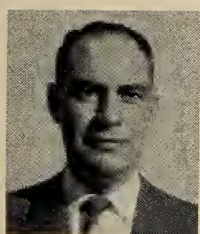
Conference on Problems of Power Generation and Transmission (ASME, AIEE), Philadelphia — September 21-23.

3rd Annual Meeting of the Water Pollution Control Federation, Philadelphia — October 2-6.

7th Annual Meeting of the Professional Group on Nuclear Science of the Institute of Radio Engineers (PGNS and Oak Ridge National Laboratory), Gatlinburg, Tenn. — October 3-5.

MARITIME PROFESSIONAL ENGINEERS' CONVENTION
Algonquin Hotel
St. Andrew's, N.B.
September 8-10

News of the Branches

New Chairmen: *(left to right)* M. Perley Estey, M.E.I.C., Fredericton; J. Longworth, M.E.I.C., Edmonton; F. R. Denham, M.E.I.C., Niagara Peninsula; J. A. Webb, M.E.I.C., Calgary.

Halifax

H. F. Peters, M.E.I.C., ***Correspondent***

TWO LARGE LOBSTERS were the delight of each member and guest at the social evening held on June 24 at the Shore Club, Hubbards. After dinner the Engineers' Wives provided entertainment for the group. Mr. H. A. Marshal, chairman of the branch, welcomed the ladies and said that it was the general feeling of the executive that there should be more such evenings.

Baie Comeau

G. W. Scott, M.E.I.C., ***Correspondent***

THE OIL INDUSTRY—from its general organization and economy in Canada to the detailed solution of technical problems associated with a modern refinery—was described colourfully by Mr. John J. Rowan, M.E.I.C., Refinery Manager of Imperial Oil Limited, Montreal, at the April 21st meeting.

Mr. Rowan's address was supported by some excellent colour slides and a sound film entitled "Refinery At Work" made at the Fawley Refinery of the Esso Petroleum Company of England.

Guest of honour at the Annual Dinner-Dance of the Baie Comeau Branch, held at Manoir Comeau, June 15th, was Mr. W. J. Thomas, M.I.E.E., M.I.Mech.E., Managing Director of The British Aluminium Company. In a spontaneous after-dinner speech, Mr. Thomas paid tribute to the engineering profession and engineers throughout the world, singling out Canadian engineers for their foresighted policy concerning the status and recognition of their profession in Canada.

Mr. Thomas was introduced by Mr. Charles Miller, vice-president of the Institute representing the Province of Quebec. Approximately 76 members were in attendance.

Brockville

D. B. Ashenden, JR.E.I.C., ***Correspondent***

THE MANY FACETS of the St. Lawrence Generating Station were explored by E.I.C. members on June 11. Accompanied by their families, 21 members and guests were introduced to the building layout by a film on the Seaway and Power Dam and then taken on tour.

The Canadian Power Station consists of 16 units of 75,000 HP, and control of the whole operation is in the hands of two control room operators. The latest in electrical switchgear and controls and a large gantry crane for maintenance services are in use.

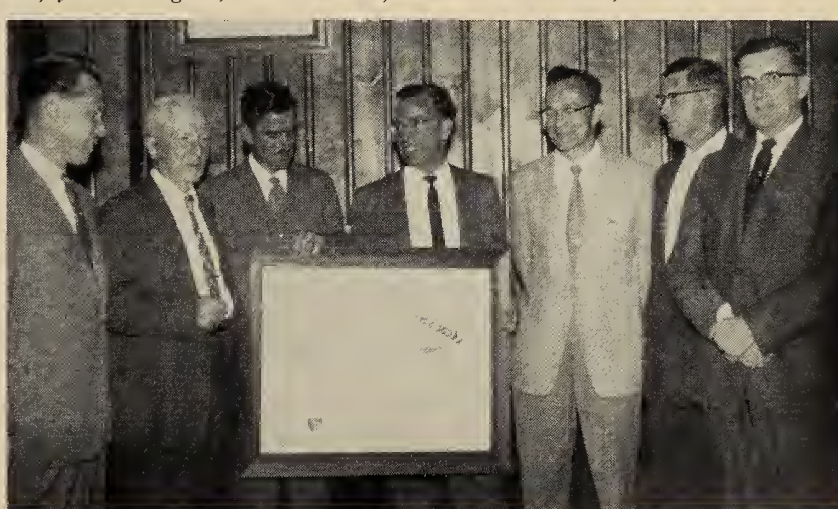
The excellent commentary and able response to questions by the Ontario Hydro engineers who acted as guides made this tour a memorable and worthwhile experience.

Niagara Peninsula

E. C. Little, M.E.I.C., ***Correspondent***

THE INTAKE STRUCTURE above the falls was the take-off point for a tour of Niagara Power Project of the Power Authority of the State of New York on June 16th. Proceeding north by bus along the twin cut for the two tubes (each about 44′ wide by 60′ high), members saw the dykes which have been partly completed and will provide a reservoir. The reservoir will be pumped up during the night by a mechanism which will also act as turbines for peak power. The forebay is well advanced and work is proceed-

The present executive of the Moncton Branch takes a look at its Charter: (left to right) D. A. Foster, vice-chairman; V. C. Blackett, secretary-treasurer; W. M. Steeves, immediate past chairman; R. F. Weir, chairman; L. R. Wadlyn, committeeman; J. F. Callaghan, committeeman; and C. L. Trenholm, councillor.



ing on the power house. The buses continued along the gorge to Lewiston where the soil disposal area is situated. During the trip guides explained each project and answered questions about the work.

North Shore Lower St. Lawrence

L. E. Fischer, M.E.I.C., *Correspondent*
NEW OFFICERS of the branch, to serve until the Fall elections in October, were elected at the April 11th meeting. They include: R. W. Pryer, chairman; R. Herbert, vice-chairman; L. Fischer, secretary-treasurer; D. O'Connor, L. Freddi, M. Storrier, D. Manston, B. Kelly and J. C. Garneau, executive members.

Ottawa

H. P. Ristow, JR.E.I.C., *Correspondent*
THE AIR TERMINAL BUILDING at Uplands was inspected by members on May 19th, through the courtesy of Mr. H. J. Connolly of the Department of Transport.

The Annual Ottawa Valley Engineers' Golf Tournament drew players from the Ottawa Branch of E.I.C. and the Professional Engineers Associations of Quebec and Ontario to compete at Arnprior Golf Club, June 24th. Ninety-eight members managed to complete the course by evening and top golfer of the day was Bob Watson from Deep River with 4-over-par 74.

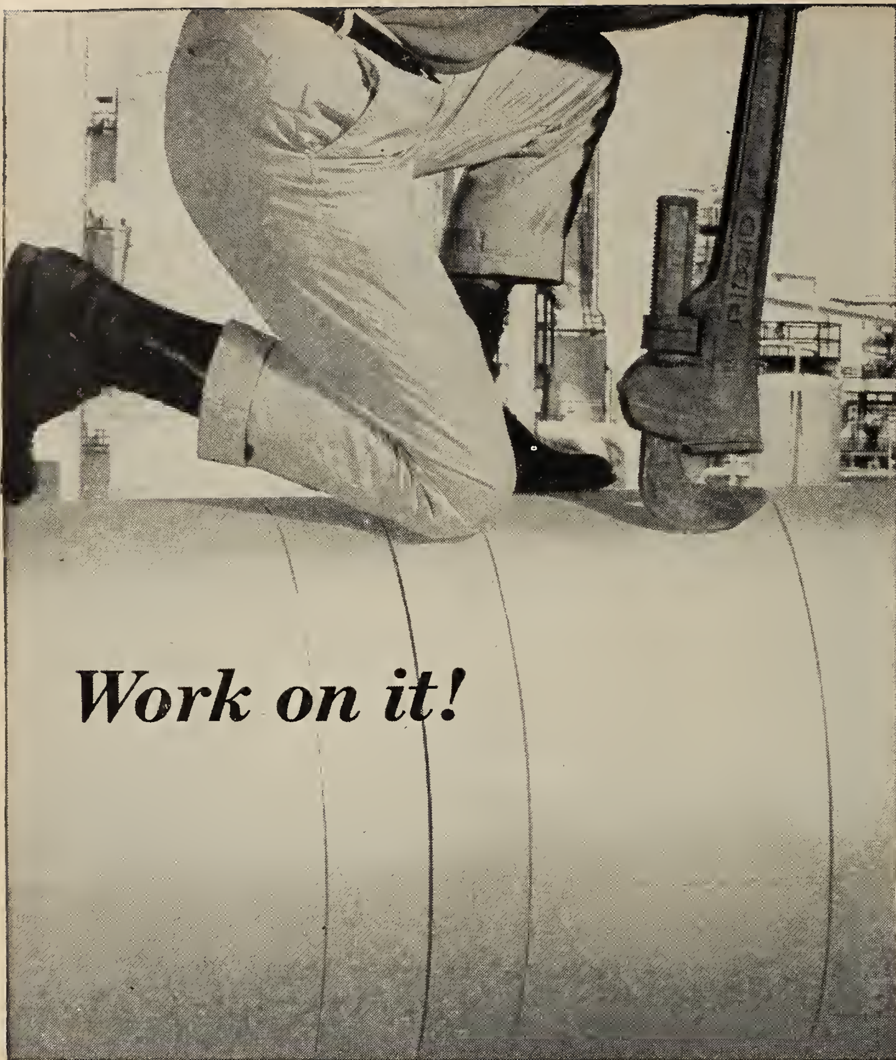
Sarnia

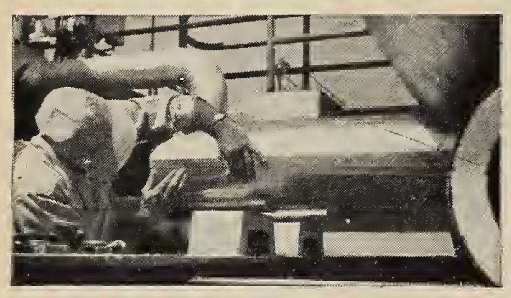
Paul Donato, M.E.I.C., *Correspondent*
ENGINEERING KNOW-HOW, according to Mr. R. A. Frigon, M.E.I.C., speaker at the May 17th meeting, could make the difference to Canada in world competition by increasing productivity through the proper employment of machinery, automation and manpower. Mr. Frigon is with the Federal Department of Trade and Commerce.

Vancouver

D. R. Bakewell, M.E.I.C., *Correspondent*
SEATTLE was the destination of 15 members and their wives attending the Annual Joint Meeting with the Seattle Chapter of the American Society of Civil Engineers on May 21st.

The new executive of the Vancouver Branch is: J. H. Swerdferger, chairman; C. H. White, vice-chairman and program manager; R. C. Clough, secretary; R. H. Carswell, treasurer; D. R. Bakewell, publicity and student guidance; S. W. Faliszewski, student guidance; H. Lillie, professional development; G. A. Antenbring, professional development; A. W. Greenius, membership; A. A. Kay, technical sections; C. H. Maartman, entertainment and field trips; C. P. Jones, past chairman; P. W. Bland, councillor; and W. G. Heslop, councillor.





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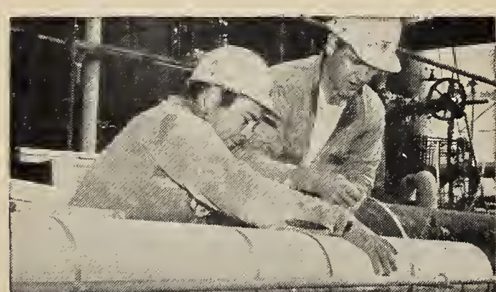

J-M Thermobestos is quick, easy to apply . . . its strength makes it particularly adaptable to time-saving prefabrication of fittings and bends. Furnished in large sections, Thermobestos reduces the number of joints needed.

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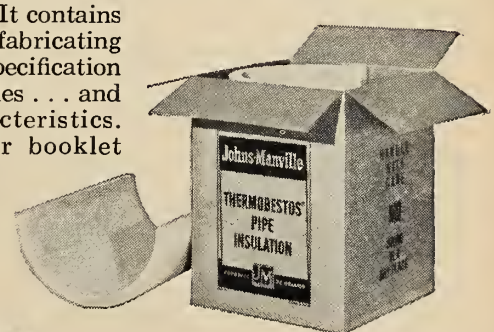

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Library Notes

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Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*PROCEEDINGS OF THE SYMPOSIUM ON MILLIMETER WAVES. (MICROWAVE RESEARCH INSTITUTE SYMPOSIA SERIES, VOL. IX)
The forty papers here published include nine not presented at the symposium. Participating were scientists from England, France, Japan, Israel, the Netherlands, the U.S.S.R., and the U.S.A. The papers discuss the present state of the use of millimeter waves in such fields as physics, communication, solid state research and metallurgy; dielectric, power, and electron profile measurements; the generation of millimeter and submillimeter waves by undulator, Cerenkov, and Purcell radiation, as well as by other means; multimodes and components; and future trends and applications of millimeter wave research. (Ed. by J. Fox. Sponsored by the Polytechnic Institute of Brooklyn. New York, Interscience, 1960. 656 p., $8.00.)

*DIRECT CONVERSION OF HEAT TO ELECTRICITY.
An edited collection of papers originally presented at the M.I.T. 1959 "Direct Conversion" program, which discuss thermionic engines, both high vacuum and low pressure, magnetohydrodynamic conversion, semiconductor devices in thermoelectrics, and fuel cells as energy converters. (Ed. by J. Kaye and J. A. Walsh. New York, Wiley, 1960. Various pagings, $8.75.)

*BEACHES AND COASTS.
The main factors on which the character of a beach depends include beach material, waves, tides, and winds; the inter-relationships between these elements are the subject of this book. The movement and grading of material and its effect on the changing profile of the beach is the main theme, and wave actions, both constructive and destructive, are covered thoroughly. Coastal types are classified and described and historical data on coastal change is given. Most examples are of English beaches, but coasts of the whole world are also included. (C. A. M. King. Toronto, MacMillan, 1959. 403 p., $11.25.)

*THE CORROSION AND OXIDATION OF METALS.
This work represents the conclusions reached by the author in his investigations into corrosion, as well as providing a summary of other experimental work which has influenced him in reaching these conclusions. The topics discussed include simple oxidation of single metals, electrochemical corrosion, soluble inhibitors, bimetallic contacts and crevice corrosion, anodic corrosion and passivation, hydrogen evolution and acid corrosion, crystallographic corrosion, and atmospheric corrosion. In addition a number of industrial aspects relating to boilers and condensers and to various types of coatings are discussed. (U. R. Evans. Toronto, Macmillan, 1959. 1094 p., $24.00.)

*SYMPOSIUM ON PLASMA DYNAMICS.
This volume is based on the 1958 Woods Hole international symposium on the variously-named science which deals with the interaction of deformable conducting materials and the electromagnetic field. The material has been arranged in individually-edited chapters synthesizing the transcript of the symposium in areas such as experimental research on high-temperature plasmas, thermonuclear fusion and high-temperature plasmas, gaseous electric phenomena, the dynamics of electron beams, statistical and continuum plasma dynamics, and flight, solar, planetary, interplanetary and cosmical magnetohydro-dynamics. (Ed. by F. H. Clauser. Reading, Addison-Wesley, 1960. 369 p., $12.50.)

*SURFACE EFFECTS ON SPACECRAFT MATERIALS.
These are the transactions of the first symposium on the requirements of materials for temperature-control surfaces of spacecraft and the behavior of material surfaces in space. Methods of calculation and measurement are first presented; the remainder of the book deals with the effects of space on the surface and structural properties of materials, and covers the sublimation of material into ultra-high vacuum, the effects of high vacuum on mechanical properties, friction and wear under ultrahigh vacuum, ultraviolet radiation in space, interplanetary dust distribution, and atomic and molecular sputtering. (Ed. by F. J. Clauss. New York, Wiley, 1960. 404 p., $11.50.)

*PROCESS ENGINEERING CALCULATIONS.
The concern of this book is the application of the laws of conservation of matter and of energy to the solution of industrial chemical process problems by the freshmen engineering student. The principles of process material and energy balance are applied here to the feed preparation, chemical reaction, and separation steps of industrial processes, but are applicable to all process operations. (M. Tyner. New York, Ronald, 1960. 402 p., $8.50.)

*THE AMERICAN CIVIL ENGINEER.
This study of the American engineer from the late 1700's through the 1840's examines the organizational pattern of nineteenth century life by describing the emergence of the civil branch as a recognized specialization in engineering. The author concentrates on those engineers who worked on internal improvements, mainly canals and railroads. He traces the careers of such men as Latrobe, Baldwin, and Brindley, the history of early New York and New Jersey canals, railroads, and such projects, and the development of the national professional association, the American Society of Civil Engineers. (D. H. Calhoun, Toronto, Saunders, 1960. 295 p., $6.35.)

*PHOTOCONDUCTIVITY OF SOLIDS.
This discussion relies more on physical description than mathematical analyses in order to foster quantitative understanding of photoconductivity. Other photoeffects in solids, such as photovoltaic and photoelectromagnetic effects are covered, and

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

Summer Library hours are: Monday to Friday: 2 p.m. to 5 p.m.; All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

description of the chemical preparation and properties of photoconductors is included. The text ranges from discussion of the basic concepts, to detailed treatment of current theoretical understanding of the mechanisms of photoconductivity and description of particular phenomena illustrating the variety of characteristics available. (R. H. Bube. New York, Wiley, 1960. 461 p., $14.75.)

***INTRODUCTION TO MODERN NETWORK SYNTHESIS.**

An undergraduate text which follows a middle path between rigorous mathematical exposition and practical applications. Among the many possible topics selection was made to ensure presentation of each in sufficient detail. Those selected include positive real functons, synthesis procedures for LC, RC and RL, and RLC cases, approximation methods, one and two terminal-pair network synthesis, and synthesis by image parameters. (M. E. Van Valkenburg. New York, Wiley, 1960. 498 p., $11.75.)

***STRUCTURAL MECHANICS.**

This book presents fundamental principles, emphasizing the mathematical treatment of structural theory bearing on indeterminate structures. It introduces advanced strength of materials, topics such as finite difference approximations, Fourier series, and structural dynamics and stability, and includes consideration of beam columns, moment distribution for axially loaded members, and numerical method for deflections and buckling. Intended primarily as an undergraduate text, but designed also to be of use for more advanced study. (S. T. Carpenter. New York, Wiley, 1960. 538 p., $9.50.)

***SYMPOSIUM ON RADIOISOTOPES IN METALS ANALYSIS AND TESTING.**

Four survey papers discuss general types of analysis using radioisotopes, such as thickness gaging, absorptiometry, radiometry, activation and isotope dilution essays, and the proper instrumentation for these methods. The remaining four papers describe current industrial activity, including the analysis of tungsten and of aluminum for trace impurities, and the training of personnel in the utlization of radioisotopes. (Philadelphia, American Society for Testing Materials, 1960. 62 p., $2.75. s.t.p. 261.)

***SYMPOSIUM ON HYDRAULIC FLUIDS.**

There are three papers on problems and trends in the use of hydraulic fluids—a general survey, and automotive and aircraft hydraulic systems, and also papers on new development and evaluation methods for marine, aircraft and industrial hydraulic fluids, including fire-resistant fluids. (Philadelphia, American Society for Testing Materials, 1960. 102 p., $3.75. s.t.p. 267.)

***LITERATURE SURVEYS ON INFLUENCE OF STRESS CONCENTRATIONS AT ELEVATED TEMPERATURES and THE EFFECTS OF NONSTEADY LOAD AND TEMPERATURE CONDITIONS ON THE CREEP OF METALS.**

The survey on stress concentration covers 1926-1957. It reviews the available notch-rupture data with the idea of establishing fundamental influences of stress concentrations, testing variables, and the influence of alloy compositions, and deals with the application of notch data to the problem of component design. The survey on cyclic loading covers 1937-1956, and describes the fundamental investigations, summarizes data on alloys under complex variations of load and temperature, and reviews several analytical procedures for calculating nonsteady behavior from steady-state stress tests. (Philadelphia, American Society for Testing Materials, 1959. 104 p., $4.50. s.t.p. 260.)

***IONIZATION PHENOMENA IN GASES.**

This graduate-level text complements others by concentrating on those discharges not previously treated collectively. The first two chapters provide a general background in describing the nucleus, ionization and excitation of the atom, spectra, conduction of electricity in a gas, and the fundamental processes of ionization and de-ionization. The remaining chapters discuss the similarity principle as applied to discharges, alternating, high current and high frequency discharges, thermonuclear effects, ionization in the upper atmosphere, and plasma oscillations and waves. Periodic tables, critical potentials, and physical constants are included in appendices. (G. Francis. New York, Academic, 1960. 300 p., $10.50.)

***HIGH PRODUCTIVITY IN HEAVY ENGINEERING.**

A book for anyone involved in the fabrication of metal by welding. The features of the different arc-welding processes are listed, with detailed consideration only of slag welding and welding of thick plate. Major consideration is given the machines for cutting and welding, methods of dimensioning, assembling, handling and inspection, and plant layout. Four final chapters discuss time standards, the use of cost data, the relation of cost to output, and productivity improvement. (A. G. Thompson. Toronto, British Book Service, 1960. 339 p., $15.50.)

***LE BOULONNAGE DES ROCHES EN SOUTERRAIN.**

The "boulonnage" or "bolting" discussed is a new technique for shoring roofs and walls of underground excavations in rock. Long bolts driven into the rock face outwards from the excavation secure flat, metal washers and often a large-mesh heavy metal screen against the rock face. The advantages, methods and materials of this technique are given, with illustrations of applications. The mathematical theory basic to it also is given, permitting assessment of its value in any specific application, and selection of the most effective type of bolt. (A. Hugon and A. Costes. Paris, Editions Eyrolles, 1959. 179p., 3035 fr.)

***TIN AND ITS ALLOYS.**

An organized compilation of eleven chapters by five British experts on the properties and applications of tin and its alloys. Describes the tin industry in general, the versatility, physical and chemical properties of the materials, their chemical behaviour during electro-deposition, hot-tinning and corrosion, and their practical uses. (Ed. by E. S. Hedges. Toronto, Macmillan, 1960. 424p., $21.50.)

***MATHEMATICAL METHODS FOR DIGITAL COMPUTERS.**

The first chapter describes methods of generation of elementary functions on digital computers. The remaining chapters each present a mathematical discussion of a particular method followed by related papers of special interest, all by authors in close contact with latest developments. The areas covered in these chapters are matrices and linear equations; ordinary differential equations; partial differential equations; and statistics. The final chapter contains six papers on miscellaneous methods, including those for numerical and multiple quadrature, and Fourier and network analyses. (Ed. by A. Ralston and H. S. Wilf. New York, Wiley, 1960. 293p., $9.00.)

*FLUID POWER CONTROL.

Following a review of fluid properties and fluid mechanics, the theory and practice of hydraulic control components, emphasizing control valves, is covered in detail. Recent progress with gaseous working fluids, particularly high- pressure pneumatics, is discussed in the final section, including systems analysis and design. Overall emphasis is on conversions, transmission, and control of fluid power under conditions for which gravitational effects are negligible. Topics discussed include flow of fluids through closed circuits, orifices and valves, variable-volume chambers, pumps, motors and accumulators. (Ed. by J. F. Blackburn and others. New York, Wiley, 1960. 710p., $17.50.)

*THE INTERNAL COMBUSTION ENGINE IN THEORY AND PRACTICE, VOLUME 1.

Volume one of this two-volume work is devoted to establishing a rational quantitative basis for design and development, and for analysis of performance. Design information in the form of curves, charts, and tables, is included for solution of practical design problems. Also covered in detail is engine friction, the relation of actual engine to ideal fuel-air cycles, air-capacity and fluid-flow characteristics of four- and two-stroke engines, and the influence of cylinder size on engine characteristics. (C. F. Taylor. New York, Wiley, 1960. 574p., $16.00.)

*INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, PUBLICATIONS 1959. NINETEENTH VOLUME.

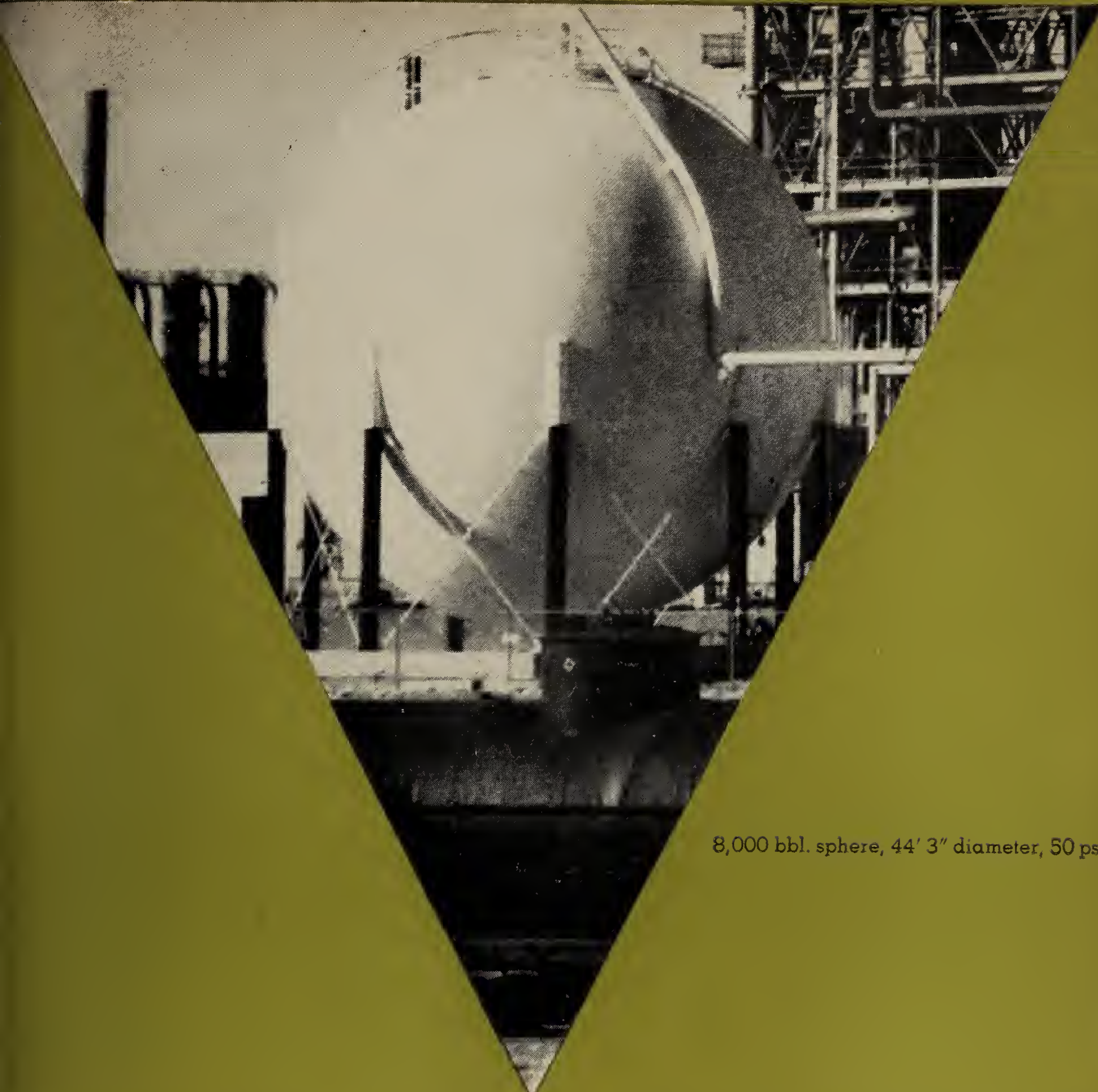
Various aspects of steel and reinforced concrete construction falling within the Association's province are the subjects of these 15 papers: the theory of trusses, of cylindrical shells, and of orthotropic plates; the plastic theory of structures; buckling loads, deformation of ring girders, boundary conditions; analysis of a skew girder bridge, design of frameworks for specific deflections; etc. Most of the papers are in English; the others have English summaries. (Zurich, Leeman, 1959. 296p., Sw. Fr. 40.00.)

*CERTAIN DYNAMIC PROBLEMS OF THE THEORY OF SHELLS.

This translation from the Russian discusses the vibrations, the dynamic stability, and the resistance-to-earthquakes of thin-walled shells, used primarily as roofs and ceilings in industrial and domestic buildings. Included is an explanation of the hypotheses and most important relations of the Vlasov engineering moment theory of shallow shells. (O. D. Oniashvili. West Newton, Massachusetts, M. D. Friedman, 1957. 178p., no price given.)

*ELEKTRISCHE ISOLIERSTOFFE, 2ND. ED.

Describes with scientific accuracy the installation, properties, manufacture and treatment of insulating materials in electrical engineering. Particular emphasis has been put on practical use in constructing machines and equipment, and typical problems are worked out in detail. There are diagrams, drawings and tables and electric stress formulas in an appendix. (A. Imhof. Zurich, Orell Fussli Verlag, 1949. 272p., 18.50 Sw. Fr.)



8,000 bbl. sphere, 44' 3" diameter, 50 psi.

*VENTILATION DES SOUTERRAINS EN CONSTRUCTION.

General material on the characteristics of and conditions in subways under construction, and the overall principles of ventilation are presented, including discussion of fans and vents. Several specific methods of ventilation, based on rigid scientific principles and experimentally proven for a wide variety of tunnel-types are described fully, along with discussion of the materials used, working conditions extant, and the economic aspects of ventilation. (P. Expilly. Paris, Editions Eyrolles, 1960. 274p., 36.55 N.Fr.)

*ARTIFICIAL EARTH SATELLITES.

Translation of information on the results of the Soviet Union's first three earth satellites. Separate papers include the data obtained in orbit, discussing methods of observation, cosmic-ray measurements, upper atmosphere and electron density, orbit parameters and other areas of upper atmosphere research. Volume I includes space biology and data on Laika, the first astronaut. Volume 2 includes discussion of similar investigations carried out with rockets. (Ed. by L. V. Kurnosova. New York, Plenum, 1960. 107p., $9.50. 2 vols. in one.)

*QUANTUM ELECTRONICS.

Advanced papers from seven nations, fully one-third of which deals with masers, their properties, types, and uses such as in amplification, pumping, time standards spectroscopy, and millimeter wave generation. Other topics discussed include relaxation processes and methods, paramagnetism, electro-magnetic amplification, molecular beams, and atomic clocks. (Ed. by C. H. Townes. New York, Columbia University Press, 1960. 606p., $15.00.)

*CHEMICAL ANALYSIS, VOLUME X: THE CHEMICAL ANALYSIS OF AIR POLLUTANTS.

Methods given here for the determination of the kind of air contaminants include general methods for sampling and for determination of volume, quantity and velocity of air and gas; analysis of settled and of suspended particulate matter; and analysis of gaseous and vapor contaminants. Methods also are given for determination of the amount of pollution emitted by any given source, such as chimneys, motor vehicles, and incinerators, and evaluation of effectiveness of abatement devices. The final chapter examines air pollution monitoring devices such as sequence absorbers, multiple gas samplers, and autometers. (M. B. Jacobs. New York, Interscience, 1960. 430p., $13.50.)

*ELECTROPOLISHING, ANODIZING AND ELECTROLYTIC PICKLING OF METALS.

This translation gives an insight into the present state of Russian technology in the metal-finishing field, giving equal emphasis to practice, application and theory, for both ferrous and non-ferrous metals. The section on electropolishing of steels reveals an advanced stage of development and of industrial application. (N. P. Fedot'ev and S. Ya. Grilikhes. Teddington, Middlesex, Eng., Robert Draper, 1959. 285p., $8.40.)

*TELEMETERING SYSTEMS.

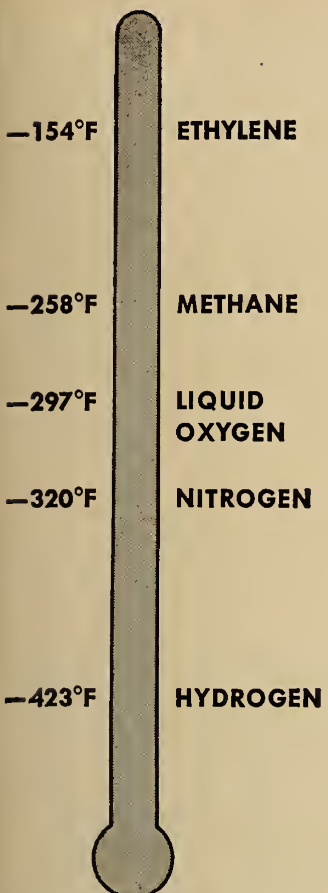
Here are presented the practical aspects and possibilities of both stationary and mobile telemetering. The latter phase, now so important in rocketry, is entirely new to this edition and is based on information in telemetering used by weapon research programs which was hitherto classified. The authors stress the similarities between the two methods of telemetering in order to point out their increasing mutual dependencies in regard to practice and techniques. The types and principles of various systems are explained: current system, voltage system, a-c and d-c position systems, and impulse systems. Pickups and channels are included, as well as the selection, application, coordination, reading, computing, and integrating of the systems. (P. A. Borden and W. J. Mayo-Wells. New York, Reinhold, 1959. 349p., $8.50.)

*BRITISH ELECTRICAL POWER CONVENTION; PROCEEDINGS, ELEVENTH, 1959.

The five long papers included in these proceedings deal with the design and growth of four British nuclear power stations, the public electricity supply and its place in the British community, the scope of installation engineering, the National Inspection Council for Electrical Installation Contracting, and the technological development in lamps and lighting. (London, The Convention, 1960. 472p., no price given.)

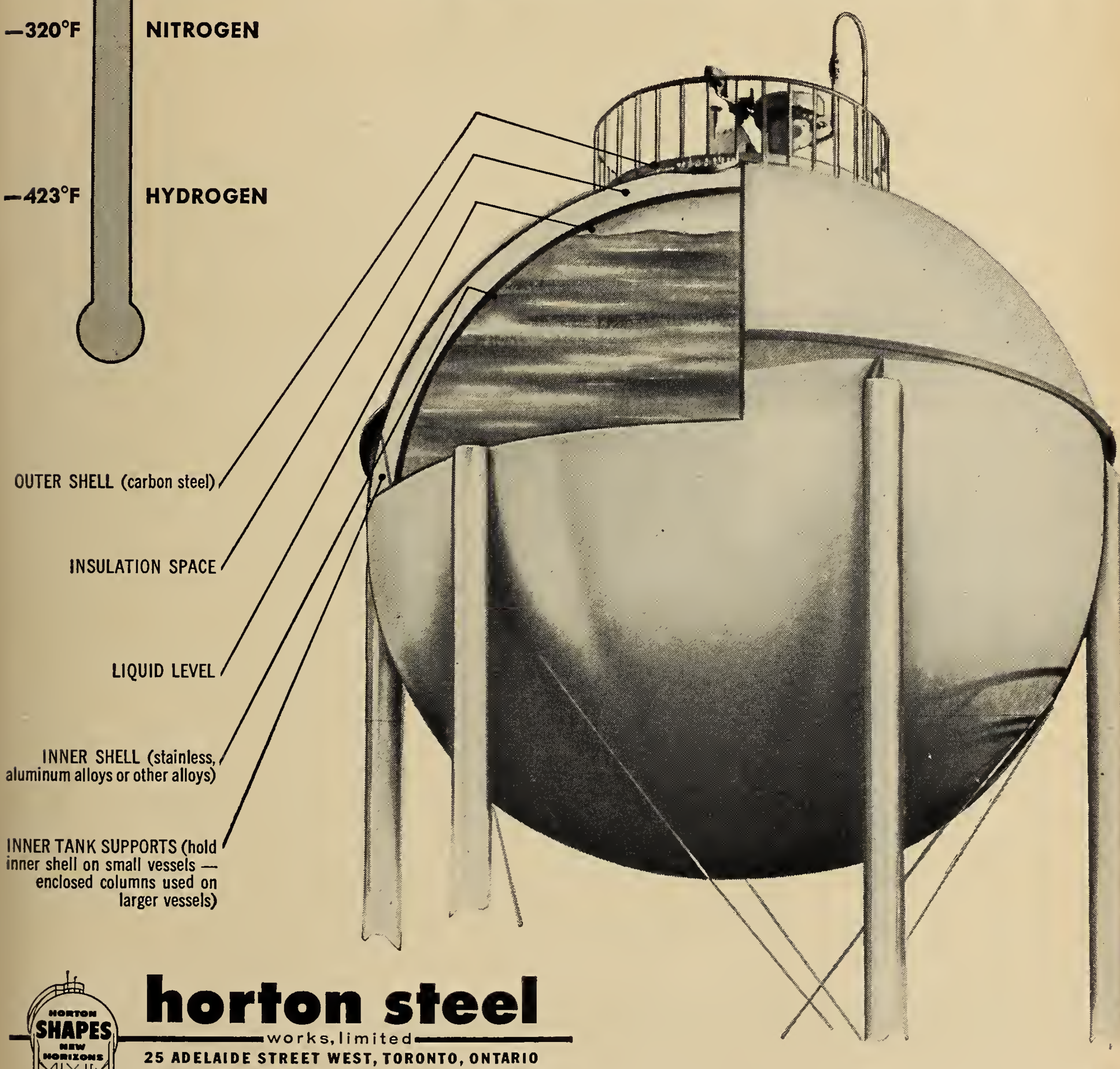
For safety and economy in LOW TEMPERATURE STORAGE

HORTON CRYOGENIC VESSELS



In the chemical process, steel and gas utility industries, the problem of storing low boiling point materials is best handled with CRYOGENIC STORAGE. Cryogenic storage vessels are actually vessels within vessels which minimize heat transfer to the inner sphere with powdered insulation placed between the inner and outer shell. Large savings result through economy in storage space.

Cryogenic storage calls for vessels of special design — and quality steel plate fabrication, metallurgical testing and control facilities. For nearly 50 years, Horton's quality code of workmanship and experience in engineering, fabricating and erecting special storage structures assures dependable cryogenic construction — to the most rigid code or customer specifications. Write today for complete details.



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HORTON DESIGNS IN CRYOGENIC VESSELS VARY TO MEET SPECIFIC NEEDS. LET US RECOMMEND A TYPE TO SOLVE YOUR PROBLEM.

• LIBRARY NOTES

***ELECTRONIC COMPUTERS, 2ND. ED.**

A British book also published in the United States, this book gives a non-mathematical general introduction to the principles and applications of computers employing tubes, transistors and other electronic devices. Almost entirely re-written with new diagrams and equipment photographs, this edition includes new chapters dealing with analog computer circuits, the programming of digital computers, and the evolution of the "intelligent" machines of the future. (T. E. Ivall. New York, Philosophical, 1960. 263p., $6.00.)

***ANALOG COMPUTATION.**

This college-level text does not require a specialized electronics background. Its general purpose is an appreciation of systems analysis, and the value of analog computation in comparison with analytical and numerical procedures. The subjects covered are: basic analog computer concepts, elements and components available, design philosophy and operating characteristics; magnitude and time scaling; solution of statistical problems and mathematical models; simulation of system adjoints; operational amplifier design problems; and detailed examples and representative applications, including combined digital analog computations. (A. S. Jackson. Toronto, McGraw-Hill, 1960. 652p., $15.55.)

***TREATISE ON THE LAW OF SURVEYING AND BOUNDARIES, 3RD. ED.**

While much of the information on surveying and boundaries in the previous edition of Clark is still applicable, changes and additional statutes and court decisions have made a new edition necessary. The chapters on public land surveys, the restoration of lost or obliterated corners, and government rules for lots and subdivisions have been considerably revised. The tracking of surveys; reading instruments of conveyance; boundaries and rights concerned with highways, lakes, streams, and rivers; pertinent state laws and court decisions, and the Canadian rectangular system of determination are other important topics covered. Footnotes referring to court decisions have been practically eliminated from this edition to save space. (F. E. Clark. 3rd. ed. by J. S. Grimes. Indiana, Bobbs-Merrill, 1959. 1031p., $12.50.)

***ELECTRONIC ENGINEER'S REFERENCE BOOK, 2ND. ED.**

This revision comes close on the heels of the first edition, published in 1958, but it has been revised and has 350 additional pages. Included are new sections on nondestructive testing, components, radiation detection, digital computer applications, simulators and electronic telephone exchanges. (Ed. by L. E. C. Hughes. Galt, Brett-Macmillan, 1959. 1588p., $18.00.)

NOTE: During the Summer months, Library hours are Monday to Friday, 2 p.m. to 5 p.m. only.

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Building codes, 1960, $3.25.
Electrical insulating liquids and gases, 1959, $4.25.
Light metals and alloys, 1959, $4.50.
Metallic electrical conductors, 1959, $4.50.
Plastics, 1959, $9.00.
Rubber products, 1960, $9.75.
Prefabrication and field fabrication of thermal insulation fitting covers, 1960, $5.00.
Rating motor fuels by motor and research methods, 1960, $7.50.

CSA Standards. Canadian Standards Association, 235 Montreal Rd., Ottawa 2, Ontario.

B19.1-1960: Specification for plain washers, $1.25.

B44-1960. Safety code for elevators, dumbwaiters, and escalators. (Second edition). $4.25.

C17-1960: Specification for alternating-current electricity meters. (Third edition) $3.25.

C22.2 No. 18-1960: Construction and test of outlet boxes, conduit boxes, and fittings. (Third edition) $1.50.

C22.2 No. 21-1960: Construction and test of cord sets and power-supply cords. (Fourth edition) $1.00.

C22.2 No. 75-1960: Construction and test of thermoplastic-insulated wires and cables. (Fifth edition) $1.50.

C22.2 No. 117-1960: Construction and test of room air conditioners. $1.50.

• LIBRARY NOTES

°PLASMA PHYSICS.

A graduate-level summary of current plasma physics. The behavior of plasmas is described first by the analysis of a single particle and then using the fluid model. These two models of description are then applied to plasma processes such as equilibrium configurations, wave-motion, instabilities and shocks, motion of plasma bunches, and the various collision, diffusion, and radiation processes operative in arriving at equilibrium. Finally, some of the applications of plasma physics to the research on the controlled fusion of light nuclei, to electronics, and to other problems in applied physics and engineering are described. (J. G. Linhart, New York, Interscience, 1960. 278p., $7.00.)

°MONORAILS.

This brief survey of monorail transportation opens with an historical account, and then discusses types of monorails, cars, track, structures, location and construction, operating characteristics, wayside equipment, and the economics of this means of transportation. There are very useful appendices, including chronological lists of constructed and proposed monorail systems, a tabulation of the dimensions and other characteristics of cars in use, diagrams of rail cross-section and rail supports, and an extensive biography. (H. S. D. Botzow, Jr. New York, Simmons-Boardman, 1960. 104p., $3.95.)

°RESIDENTIAL CONSTRUCTION MANAGEMENT.

The dramatic changes taking place in residential construction as it evolves from a trade to an industry present a range of management and construction problems. The structure of organization follows a statistical background and projection; the author then examines methods of preparing land for construction, development of land, plans, specifications, estimates and budgets. Construction scheduling is examined, with one system described in detail, and with emphasis on work control. Other chapters deal with subcontracts, material control, sales, and cost accounting, discussing general concepts together with suggestions for specific procedures. (E. L. Buckley. New York, Wiley, 1959. 193p., $7.95.)

°THEORIE DER ELASTISCHEN VERFORMUNG.

The elastic deformation of basic structural elements is thoroughly analyzed from the mathematical point of view. Section I covers the general development of elastomechanics-distortion and stresses and the relation between them, energy of deformation, etc. Section II presents analyses of some nine different types of problems dealing with torsion and bending of rods and plates, shell theory, elastic stability, vibration problems, and wave phenomena. (W. Muller. Leipzig, Germany, Akademische Verlagsgesellschaft, 1959. 327p., 31.50 DM.)

°RADIATION PYROMETRY AND ITS UNDERLYING PRINCIPLES OF RADIANT HEAT TRANSFER.

The first three chapters discuss the principles of the emission, absorption, reflection, and transmission of thermal radiation, excluding aspects not particularly applicable in pyrometry. The characteristics of high and low temperature radiation pyrometers then are dealt with, including calibration, lenses, mirror design, field of view, and ambient temperature variation effects and compensations. The application of emittance corrections then are described, and the final chapter contains tables, such as of relevant mathematical relationships, calibrations, optical characteristics of some substances, and radiation functions. (T. R. Harrison. New York, Wiley, 1960. 234p., $12.00.)

°REPORT ON MARINE ATMOSPHERE EXPOSURE OF GALVANIC COUPLES INVOLVING MAGNESIUM.

This publication reports the results of exposure tests of protective systems for magnesium, including chromate conversion, anodic coatings, and paint systems of chromate prime and alkyd, phenolic, and epoxy resins. (A. Galleccio and I. Cornet. Philadelphia, American Society for Testing Materials, 1959. 26p., $2.25. s.t.p. no. 255.)

PRODUCT DESIGNERS

Interesting positions are now available in our product development Engineering Group. These positions, located in Toronto, involve the design and development of new products in the Plumbing and Heating field.

We are a large, multi-plant manufacturing firm making boilers, furnaces and plumbing ware. University Graduates in Engineering or equivalent with 1 to 3 years experience preferably familiar with plumbing and heating products, are required. Good starting salary and many employee welfare benefits. Reply in confidence, enclosing resume, to File No. 7060-V.

nical institute in the field of mining and civil engineering. All further details may be obtained by contacting directly, Bureau of Personnel, UNESCO, Place de Fontenoy, Paris 7, France, or by applying to File No. 7091-V.

SALES ENGINEERS required by a leading member of the compressed gas industry. Applicants should have graduated 5 to 10 years ago, preferably in Chemical, Electrical, Metallurgical or Mechanical engineering. Subsequent experience in the welding industry or in metal fabrication desirable. These are challenging positions in our Head Office, Montreal. Replies will be kept in strict confidence. A resume stating business experience, education, salary requirements, etc., should be sent to File No. 7092-V.

SALES ENGINEER as Montreal Branch Manager, handling air and dust filtering and other industrial equipment. Bilingual preferred. Three to five years' sales experience. Salary plus commission. Interviews Montreal and Toronto. File No. 7094-V.

SALES ENGINEERS, three recent graduates, mechanical, electrical or chemical required by leading manufacturer of air conditioning and ventilating equipment, shell and tube heat exchangers and related engineered products. Following completion of Company training course successful applicants will be assigned to Hamilton and Montreal Branch Sales Offices. Attractive starting salary and wide range of Company welfare benefits. Send complete resume and salary requirements. File No. 6923-V.

ELECTRICAL ENGINEER

The CITY OF REGINA has an opening for a Graduate Electrical Engineer with one or two years' experience, preferably in the Light and Power field. Salary Range: $5,040 to $6,432 per annum, commensurate with qualifications of successful applicant.

Applications and enquiries should be directed to the PERSONNEL DEPARTMENT, CITY HALL, REGINA, SASK.

ENGINEERING SALES

Positions open in a rapidly growing company for high calibre sales representatives.
A degree in Engineering or Science, preferably emphasizing Chemistry and obtained since 1955, is desirable. Relocation and travelling required.
Remuneration above average and advancement possibilities good.
Kindly apply in writing, outlining academic qualifications, experience and interview availability.

ALCHEM LIMITED
Burlington, Ontario
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Water Conditioning Chemicals & Services • Coagulants • Petroleum Chemicals • Corrosion Inhibitors • Antifoams • Microbiocides.

OPPORTUNITY FOR

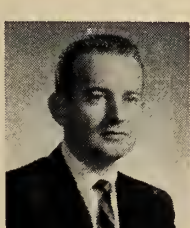
CHIEF ELECTRICAL ENGINEER

Electrical engineer required with wide experience in electrical design of hydro-electric stations and transmission lines, to take charge of electrical design department. Ability to organize an effective engineering team is important. Reply to:

SANDWELL INTERNATIONAL LIMITED
1512 ALBERNI STREET, VANCOUVER, B.C., CANADA

• MORE PERSONALS

W. James Bichan, M.E.I.C. (Royal School of Mines '32), Vice-President, Mining and Geological Divisions of Beaco Ltd., has been in the West Indies for Canadian Engineering (International) Ltd. as technical adviser to the Government of Trinidad and Tobago.

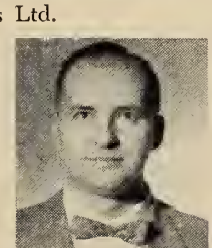


W. D. West, JR.E.I.C.

W. D. West, JR.E.I.C. (Queen's '55) has been appointed Technical Representative, special accounts, for the Marketing Division of the RCA Victor Company Ltd., Montreal.

D. F. Coates, M.E.I.C.

D. F. Coates, M.E.I.C. (McGill '48), consulting civil engineer, has been appointed a director of W. S. Atkins and Associates Ltd.



J. B. Herbich, M.E.I.C.

John B. Herbich, M.E.I.C. (Edinburgh '49) has been promoted to the rank of Associate Professor in the Department of Civil Engineering, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.

Murray Zides, M.E.I.C. (New Brunswick '44), Director of the Town Planning Commission of Metropolitan Saint John, was recently elected to the presidency of the Town Planning Institute of Canada.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Address all information to: *The Engineering Journal,* Editorial, 2050 Mansfield Street, Montreal, Que.

Business and Industrial Briefs

Appointments and Transfers

F. Gordon Holroyd has been appointed Operations Manager of Macdonald & Macdonald Ltd., Inspection and Testing Engineers.

James Warren Quarles has been named Technical Sales Representative to the Eastern Sales District of Carbide Chemicals Company, Division of Union Carbide Canada Limited. He will be handling the sales of "Union Carbide" Brand polyethylene resins and compounds.

The appointment of **R. J. Norton** as Ontario Regional Manager, Technical Products Marketing Division, RCA Victor Company, Ltd., has been announced.

L. Grant Bragg has been appointed Manager of the Toronto office of Research-Cottrell (Canada) Ltd., manufacturers and distributors of industrial gas cleaning equipment.

H. J. Cameron has been appointed Product Manager, Pipe Department, of Atlas Asbestos Co. Ltd., Montreal. He will be responsible for merchandising "Turnall" Asbestos-Cement Pressure and Sewer Pipes throughout Canada.

Paul N. Heald has been appointed Manager, manufacturing operations, of Shell Oil Company of Canada, Limited, and will make his headquarters at the head office in Toronto.

Douglas Lee has been made Manager of the Canadian Westinghouse power transformer and circuit breaker division, Hamilton.

C. Wondolowski has been appointed Works Manager of the Toronto Eastern Avenue Plant of Canadian Iron Foundries, Limited. **Arnold Henry** is the new Works Manager of the St. Thomas Plant.

W. H. Irwin, vice-president of the Canada Metal Co. Ltd., was recently elected a director of the Canadian Copper & Brass Development Association.

Establishment of Washington representation for the Aeronautical Group of companies of A. V. Roe Canada Limited has been announced. **John R. Douglas**, formerly the Canadian Government's Washington Representative for the Department of Defense Production, has been appointed to administer the new office.

Patrick E. Cavanagh has been appointed President and a director of Premium Iron Ores Limited, Montreal. The company is engaged in studies of an iron ore reduction plant to produce metallic iron at the Lakehead with natural gas.

CANADIAN PERSONNEL and equipment will be at work on a project in the United States for the U.S. Atomic Energy Commission. The American subsidiary of the Cementation Company (Canada) Limited. has been awarded a $765,000 contract by the Commission foı shaft-sinking and tunnelling in connection with an atomic explosion designed to further the peaceful uses of nuclear energy. The explosion is expected to create an underground storehouse of heat from which energy will be derived. T. H. Blair, executive vice-president of both the Canadian company and the U.S. subsidiary, said his firm had won out over eight others because of its experience in dealing with water-bearing strata which are anticipated in the first section of the shaft sinking. Personnel of the Canadian firm are already at work in uranium deposits at Grants, New Mexico, and in a salt mine at Cleveland, Ohio.

A MEMORY UNIT of the magnetic core type used in high speed electronic computors has been installed at the University of Houston as an experimentation and training aid in computor technology. Presented by Telemeter Magnetics, Inc., and valued at nearly $10,000, the unit has 24 core arrays, each with over 4,000 cores, and provides storage for 100,000 information items. It is wired to provide for writing and reading information into and out of the unit at rates up to 125,000 operations per second.

New Developments

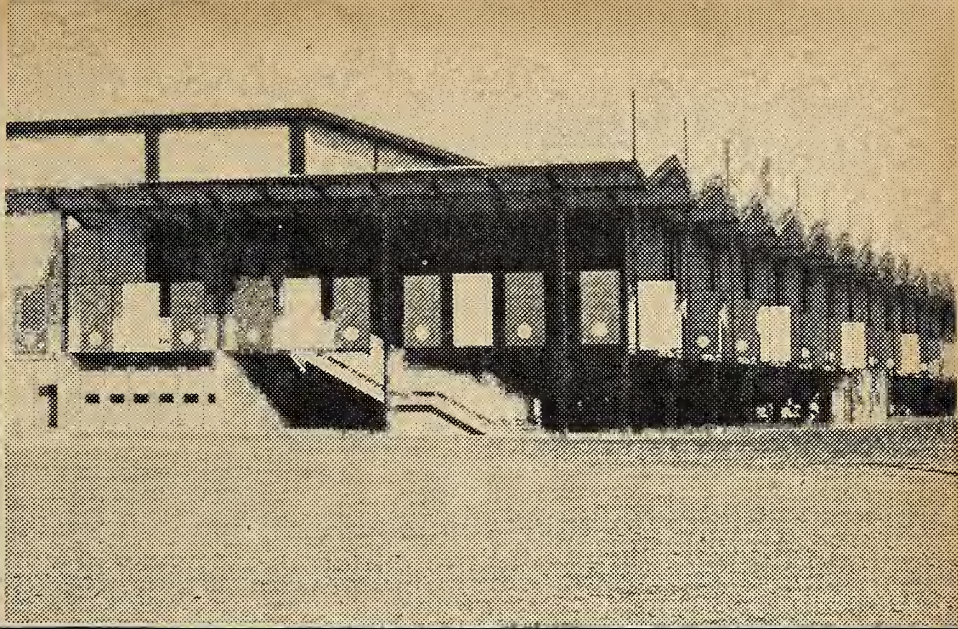
THE DEEP-PLEAT design of Farr's new HP series of folding, disposable media filters provides larger media area in a compact, preformed, folding filter cartridge. The new filters were especially developed to operate at the lowest pressure drop without loss of efficiency or dirt holding capacity, and are designed for any commercial or industrial ventilating or air conditioning system requiring high efficiency air filtration with low maintenance costs.

CORKTITE, normally an underfloor insulation and cushion where concrete is placed directly on the ground has been employed as an insulating material for a stainless steel curtain wall in Toronto's new Union Carbide building. The architects had specified insulation between interior structural steel mullions and the extruded aluminum exterior mullion, to ensure a positive thermal barrier by isolating the interior and exterior metals.

MINIATURE SOLDERING INSTRUMENTS are the business of Len Finkler Ltd. of Toronto. A new addition to their Oryx line is claimed to be the smallest 115V iron in the world. It comes in two models — the 115-10 which heats to 672°F. in 70 seconds with a 3/32 in. tip and 115-15 w. which heats to 717°F. in 50 seconds with a 7/32 in. tip. No transformer is required.

A SINGLE ELECTRON is now made visible by means of a small electronic tube with a light-sensitive screen at its input end. Individual particles of light, photons, are directed onto this screen, strike its surface and eject electrons from it. Each ejected electron is accelerated forward by 2000 volts and strikes head-on into a thin two-layer film, penetrating its insulator layer and releasing four or five additional electrons. The resulting electrons are aimed at a thin layer of fluorescent material at the output end of the tube. Thus the light striking the input photosurface is reproduced thousands of times brighter at the output end. The tube, designated as the Astracon, is a Canadian Westinghouse product.

FRANKI FACTS



CLIENT:
Calgary Exhibition & Stampede Association

LOCATION:
Calgary, Alberta

ARCHITECTS & ENGINEERS:
J. Stevenson & Associates, Calgary

GENERAL CONTRACTORS:
Burns & Dutton Concrete & Construction Co. Ltd., Calgary, Alberta

TYPE OF STRUCTURE:
Curling Rink and Exhibition Building

NUMBER OF FRANKI UNITS:
217 Franki Pressure Injected Footings

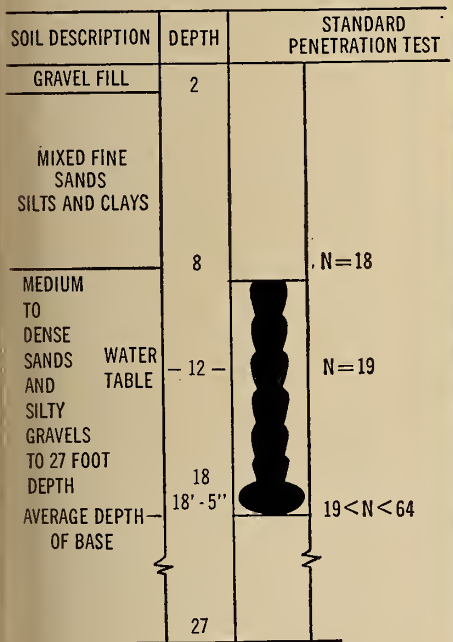
WORKING LOADS:
18 to 108 tons

AVERAGE LENGTH OF FOOTINGS:
Driven 18′-5″, Concreted 10′0″

SOILS INVESTIGATION:
Materials Testing Laboratories Ltd.

Franki caissons provide uniform bearing in erratic melt water deposits

TYPICAL BORING LOG



NOTE: 19<N<64 means "N" is more than 19 and less than 64

Problem

The site of the new BIG FOUR BUILDING at the Calgary Exhibition and Stampede Grounds lies in an old glacial melt water channel where the soil profile shows considerable variation in horizontal stratification normally found with river deposition. Test holes indicated a wide range in density in the interbedded layers of water bearing gravels, sands, silts and clays with no correlation between the test holes. This two story structure, designed to accommodate 48 sheets of curling ice, could not tolerate even the smallest differential settlement. Column loads up to 210 tons had to be transferred to a suitable bearing deposit.

Solution

Franki Caissons were chosen to support the structure as the Franki method alone can provide uniform bearing at a given depth in granular soils, regardless of the relative density of the deposit in which the base is made. This bearing is guaranteed by measuring the amount of energy expended in ramming into a bearing deposit, 5 cu. ft. batches of zero slump concrete. Concrete charges of this volume are added until 20 blows of 140,000 ft. lbs. are attained to expel the last 5 cu. ft. This criteria provides 120 ton bearing capacity.

Compaction of the granular deposits, which varied widely in density, provided even bearing throughout the site at medium depths, thereby affording the owner a safe economic foundation.

Literature-This series of job highlights, as well as other descriptive literature, will be sent to you upon request to Franki of Canada Ltd., 187 Graham Blvd., Montreal 16, P.Q.

SPRAY METHOD ROOFING of flat and free-form surfaces was publicly demonstrated for the first time recently by The Flintkote Company at its research laboratory in Whippany, N.J. The Sealzit Spray Gun jet installs roofing in a single operation rather than by the ordinary method of building up layers of roofing. A three-man crew using the gun can install between 15,000 and 18,000 sq. ft. of material a day.

BULLETIN 175, just published by Clark Bros. Co., N.Y., one of the Dresser Industries, introduces the "Isotemp" Packaged Centrifugal Air Compressor line for air separation plants and industrial use. These compressors are built in six frame sizes with horsepowers ranging from 1000 to 8000 and capacities from 5000 to 38,000 cfm.

COMPONENT MINIATURIZATION has shown new possibilities in a compact servo amplifier produced by Lear Incorporated, Grand Rapids, Michigan, which can perform reliably under severe environmental conditions. The module, contained in a package with a total volume of less than a cubic inch, is being used at Lear for positioning gimbals, gyros, platforms, and compass systems.

THE SWITCHING SURGES and high reverse voltage stresses previously met in T.V. H.T. circuits have been overcome by a new 1000 volt-tested SIMET Silicon Rectifier put out by The Plessey Company Ltd., England. The 1000 volt test gives almost 50% over-voltage protection against the normal 700 P.I.V. maximum obtained in a television receiver on 250 V. AC mains.

A LOW-BED TRAILER for heavy duty work is announced by LaCrosse Trailer Corporation, LaCrosse, Wisconsin. The three-axle trailer is of single point suspension design. LaCrosse's thru axle tandem assembly is coupled to the third axle by a walking beam and two-way oscillation provides uniform distribution of weight even when single wheels are raised or lowered by uneven ground.

A CHIMNEY 490 ft. high is rising on the lakefront just west of Metropolitan Toronto. The first of three such chimneys, it marks Ontario Hydro's coal-fired Lakeview generating station, the largest thermal-electric power project in the world. Each stack will effectively disperse combustion gases from two of the plant's generating units. The $250,000,000 station will be operating in 1960 with an expected capacity of 1,800,000 kw. from six units.

LOW TEMPERATURE IMPACT upon four nickel steels is outlined in a 32-page booklet distributed by The International Nickel Company of Canada, Limited. It points out that since nickel in normalized steels effectively lowers the impact transition temperature, these steels are ideally suited for handling liquified gases at low temperatures.

ELASTOMERIC ROOFS, their coatings made from neoprene and synthetic rubber, have recently been introduced into Canada by Dupont of Canada Limited. They have demonstrated exceptional resistance to weather, abrasion, chemicals, ozone and the ultra violet rays of the sun. Applied in fluid form, these roofs lend themselves to the unusual geometric forms of modern building. They are non-inflammable.

GROUT FAILURE is most frequently caused by shrinkage. The Master Builders Company has published a 16-page booklet on grouting techniques with *Ebeco* non-shrink grout — common methods of grouting different types of equipment, the mixing and placing of grout, and cold and hot weather grouting. Bulletin E-1d can be obtained from: The Master Builders Company, Ltd., Toronto 15, Ontario.

EXPANDING motor control facilities are being made available at Canadian Allis-Chalmers' St. Thomas, Ontario plant with the completion of the new $100,000 addition. A line of 0 to 4 low voltage motor control will be manufactured there and distributed by Canmark Services Limited. Unitized construction in the new line of contactors allows building-block modification, and standard, special design, and accessory control devices are available for application from 110 to 600 volts for fractional to 200 hp. motors.

FLOODLIGHTING is the subject of a recent 61-page Canadian General Electric catalogue. PAR, general purpose heavy duty, underwater, fluorescent and mercury floodlights are described in this book, as well as mercury ballasts and mercury lamps. One section deals with calculating lighting requirements and laying out good lighting installations. Catalogue No. FL-60 can be procured from: Lighting Equipment Sales, Canadian General Electric Company Limited, 830 Lansdowne Avenue, Toronto 4, Ontario.

CONTROL REQUIREMENTS of hydraulic machinery may be met by a new solenoid operated 4-way directional control valve which is being produced by Vickers Incorporated, Detroit, Michigan, Division of Sperry Rand Corporation. Furnished with ⅜ in. ports (or ½ in. to take advantage of larger flows), the valve has a nominal rating of 8 gpm and can handle flows up to 12 gpm. It is rated for 115 volt, 50 or 60 cycle a-c service.

A PNEUMATIC CONTROLLER regulates the new Wallace and Tiernan metering pump. In response to an air signal from a W&T Merchen gravimeter feeder caused by varying the flow rate of dry solids through the feeder, the controller will automatically adjust the pump's stroke length to give varying rates of flow of the metered liquid. It bolts onto any run-adjust model of W&T Series 200, 400 or 600 pump, in place of the normal adjusting handle, and makes the process entirely automatic.

A NEW REFINERY at Rimbey, Alberta is to be equipped with 18 industrial steam turbines from Canadian Westinghouse, including the two largest compressor-drive turbines ever built in Canada for this type of application — rated 2500 hp. at 7500 rpm. Also among the 18 units are three 1250 kw. turbine-generators. The plant, owned by 25 companies, will process up to 326 million cu. ft. of gas daily from the Homeglen-Rimbey and Dick Lake fields.

AN INERTIAL DAMPER that can be coupled to the mating servo motor in a matter of seconds is being produced by the Industrial Control Company, Inc. The motor's mounting register fits into the rear of the damper and its pinion drives the damper element. The 1D-15-100 can be used without mechanical changes in an existing gear train to raise the loop performance above that possible with a simple motor.

A FLOATING COVER for sewage digesters, composed of rectangular steel plates field-welded into a single deck without trusses, is being put out by Infilco Inc., manufacturers of water, sewage and waste treating equipment. The steel plates are ¼ in. thick, while insulation is of 1½ in. thick fibreglass material. A weighted pontoon around the periphery gives torsion, bending and compression.

A BALLOON-PARACHUTE system has been developed by Goodyear Aircraft Corporation for the Air Research and Development Command's Wright Air Development Division. The spherical drag balloons are to be used to retard tumbling and to control speed of instrumented nose cones, manned escape capsules and other orbital vehicles during re-entry through the heat barrier of the earth's upper atmosphere.

ELECTRONIC COOLING is achieved by a new refrigeration unit which has been produced by The Garrett Corporation's AIResearch Manufacturing Division at Los Angeles. The Peltier cooling device dissipates 65.3 watts of heat to ambient air at 140°F. at sea level, maintaining temperatures below 110°F. Heat generated by gyro servo components is transferred via internal air and conduction to a stable platform aluminum housing from which it is drawn out by thermoelectric couples and vented overboard through a plate and fin heat exchanger.

A CAM PROGRAMMER coordinates the operations of the new high temperature furnace being produced by The Electric Hotpack Company, Inc., Philadelphia. High retention insulation keeps thermal levels even, and a high velocity blower and counter-weighted exhaust stack facilitate rapid evacuation of heat from the chamber during cooling cycles. Both the wattage selector switch and timer and the blower switch are synchronized to the programmer for automatic cooling cycles.

RECLAIMING CRANKSHAFTS — grinding, shot peening, chrome plating and balancing extra large shafts of the size used in diesel engines and big compressors — are all operations of the new facilities at Montreal Locomotive Works, Limited. A huge crankshaft grinder equipped with automatic load compensators, weighing over 15 tons, is one of the new pieces of equipment at the Longue Pointe plant.

A CIRCUIT BREAKER, half the size of previous breakers, has been announced by Eastern Power Devices Limited, Toronto. The new moulded case circuit breaker, designated FJ-frame, provides the ratings and features of the J-frame, but is 4½ in. x 10 in. while the J-frame is 9" x 11". It is available in two- and three-pole construction in current ratings of 70 to 225 amperes, 600 volts a-c and 250 volts d-c.

SATIN FINISHES in the metal industries can be achieved with no special equipment or compounds with a finishing material produced by Minnesota Mining and Manufacturing of Canada Limited. This "Scotch-Brite Brand" finishing material is made of non-woven nylon web ¼ in. thick impregnated with fine abrasive grains.

A NON-HARDENING glazing compound, "Speedglaze", has been developed by Stelco. Tested under radiation conditions approximating noon June sunlight with periodic spraying of water at controlled temperature and pressure, the new product has proved its ability to resist long periods of outdoor exposure. It adheres well to metal or wood and will resist wrinkling and cracking.

THE GENERAL OFFICES of the Linde Gases Division of Union Carbide Canada Limited are now situated in the Union Carbide Building, 123 Eglinton Avenue East, Toronto 12.

A CANADIAN COMPANY, Multitone of Canada Limited, supplied a unique pocket paging system for use at the Democratic National Convention in Los Angeles. Delegates, officials and TV network and news service personnel were provided with tiny pocket receivers enabling them to be called at any point in the proceedings regardless of their location. A closed radio circuit with a central transmitter and as many receivers as needed (each on its own separate wave length), the Multitone Personal Call System has already been installed widely in hospitals and factories.

A CHANGE of name has been effected in F.S.B. Heward & Company Ltd., 3285 Cavendish Boulevard, Montreal 28, and the company is now Canapower Thermal Specialties Ltd. It continues to represent leading manufacturers for the sale, service, installation and operation of steam plant, industrial and marine equipment.

(more Briefs on page 135)

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WANTED

July 1960 issue of

THE ENGINEERING JOURNAL

The Engineering Institute has received so many requests for additional copies of the July issue of The Engineering Journal that the available supply has been exhausted.

It will be greatly appreciated if readers who do not keep their copies on permanent file, will return them to the editorial office at 900 Sherbrooke Street West, Montreal 2, Que.

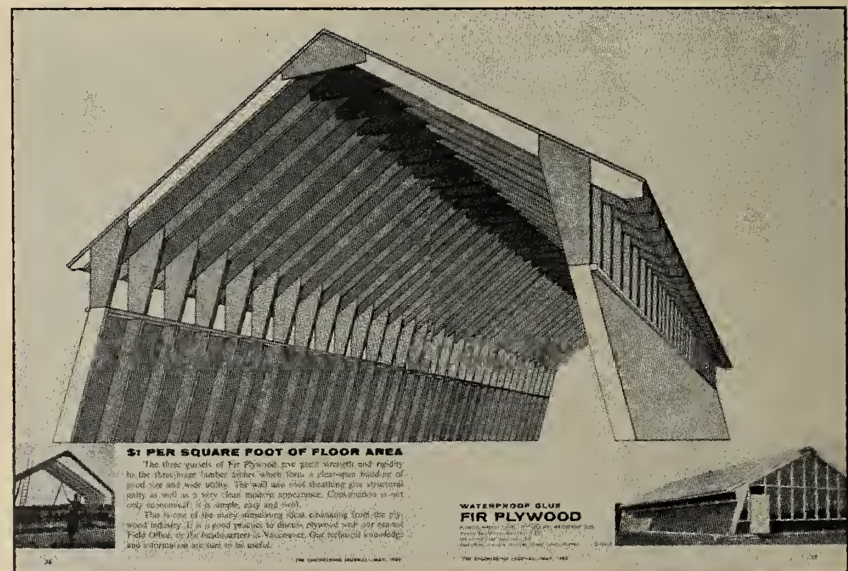
E.I.C. CERTIFICATE OF ADVERTISING MERIT

PLYWOOD MANUFACTURERS ASSOCIATION OF BRITISH COLUMBIA WINS CERTIFICATE

A two page, two color, advertisement prepared by the Vancouver office of McConnell, Eastman & Co. Ltd. for the Plywood Manufacturers Association of British Columbia was judged the "best" in the May issue by a jury of fifty readers. Judging was based on ACCURACY–INFORMATION and ATTRACTION and the jurors represented every province of Canada.

The advertisement presents a striking two color line drawing and is headed: "$ PER SQUARE FOOT OF FLOOR AREA". The copy describes the type of construction illustrated in the advertisement. The advertiser will be pleased to send readers of the "Journal" copies of literature illustrating and describing the various uses of plywood for engineering work.

The Advertising & Publicity Manager of the Company is Mr. C. J. Hempsall and the Advertising Agency who placed the winning advertisement is McConnell, Eastman & Co. Ltd., Vancouver, B.C. — Mr. Clarke Wallace, Vice-President.



Reproduced above, on a greatly reduced scale, is the two page, two color advertisement of the Plywood Manufacturers Association of British Columbia which was judged the "best" in the May issue. It appeared as pages 36 & 37 of the issue.

● MORE BRIEFS

A TRANSISTORIZED SHIRT-POCKET RECEIVER applicable to any situation where instantaneous verbal contact is required—general manufacturing, agriculture, construction and mining, to take but a few examples—is being produced by Canadian General Electric. The person wearing the 12-ounce receiver can be contacted instantly by a base station transmitter, a two-way radio car or by a portable unit, all operating at the same frequency.

EXPLORATION AND SURVEY FLYING will be performed across Canada by the new company Survair Limited, with home base at Uplands Airport, Ottawa. Their S-55 Sikorsky helicopter, two Piper Apaches, and a Cessna 182, equipped with the newest Swiss mapping cameras and airborne geophysical instruments, will do the job.

CONTINUOUS BRIGHT ANNEALING of stainless steel strip is made possible by the new high-production furnace produced by Canadian General Electric. A cost-lowering is promised by improved surface appearance, corrosion resistance and physical properties of the annealed strip. Through utilization of very pure and dry hydrogen or dissociated ammonia atmosphere, the bright annealing furnace prevents the formation of scale on the strip.

MATERIAL PREPARATION OPERATIONS and warehouse functions will be carried out by the new addition to the St. Thomas, Ontario Works of Canadian Allis-Chalmers completed in June. A new line of low voltage motor control will be processed there, motor and switchgear assembly facilities will be expanded and the present lines manufactured by the St. Thomas plant will be increased.

AN OPEN STEEL PLANK which will combine with Dexion angles to provide strong, load-bearing floors, ramps, catwalks, stair-treads, mezzanines and platforms is the newest product to be added to the Dexion (Canada) Ltd. slotted angle construction system. Available in 4′6″ or 6′ lengths, each unit is 9″ wide, pressed from a single slab of 16-gauge mild steel.

THE INSTRUCTIONAL SERVO SYSTEM manufactured by Feedback Ltd. of Servomex Controls Ltd. is being used in many universities and technical schools in the U.K. to demonstrate control system theory. The Servo Control Unit and Servo Assembly can be used directly to work out important aspects of basic theory and, with additional test equipment, can take detailed measurements on frequency response and transient response in both openloop and closed-loop conditions.

A CURLING AGENT and seal for concrete floors, eliminating constant wetting down of concrete during the curing stage, is being produced by The Tremco Manufacturing Company, Cleveland and Toronto. In one application this new product gives a high degree of water retention in the concrete while the proper cure takes place. The agent, "Tremcrete", permits application of paint, linoleum, asphalt tile and other materials. It dries to tack-free stage in two to three hours.

A MORE POWERFUL VERSION of the Bristol Siddeley Olympus turbojet, the standard engine for the RAF's Vulcan V-bomber, has been announced by the company. The engine has a thrust without reheat of 20,000 lbs. and is the most powerful British military aircraft engine in existence today. Developed from the earlier 17,000 lb. Olympus 201, this latest engine has an extra stage on the front of the low pressure compressor and a shorter air intake.

THE CREOSOTE INFORMATION BULLETIN prepared monthly discusses the nature and application of the wood preservative Creosote, a product of the Coal Tar Products Division, Dominion Tar & Chemical Company, Limited. More than 100 chemicals toxic to fungi are combined in Creosote; thus although living matter in time becomes immune to the harmful effects of a single chemical, it is unlikely that fungi could overcome the multiplicity of toxic ingredients.

EPOXY COATING has been used on the 42-inch-diameter steel pipes being laid for the fast growing community atop Hamilton, Ontario's mountain. The pipes, forming a water main which runs some 900 ft. horizontally into the face of the mountain and approximately 200 ft. vertically to the summit, are prepaired for coating by a fine sand blast and kept at a temperature not less than 50 degrees F. for application of the resin paint. Sparling Tank & Manufacturing Co., New Toronto, supplied the pipe and did the inside and outside welds.

NEW MANUFACTURING FACILITIES for cylinders have been established by Vickers Incorporated, Division of Sperry Rand Corporation, in Waterbury, Connecticut. Designed for manufacturing standard hydraulic cylinders for the industrial and marine and ordnance fields, the new plant includes complete engineering, manufacturing, processing, raw stores, and warehousing facilities.

A LIFE SCIENCES DIVISION has been added to the facilities of Arthur D. Little, Inc., large private industrial research company with headquarters in Cambridge, Mass. Under the direction of Dr. Charles J. Kensler, the new division will investigate uses of biology in industrial processes and in evaluating effects on man and animals of industrial products.

STEEL RINGS are being used rather than conventional cast-iron tunnel supports in construction of the Callahan Tunnel under Boston Harbour. Use of the rings was made practicable by applying a protective coating of Bitumastic 70-B coal-tar enamel, developed by Koppers Company, Inc., to the eleven steel plates which make up a ring section.

Index to Advertisers

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed below are the names of the Companies and Individuals whose advertisements appear in this issue.

AUGUST, 1960

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THE ENGINEERING JOURNAL
PUBLISHED MONTHLY BY THE ENGINEERING INSTITUTE OF CANADA VOLUME 43 NUMBER 9 SEPTEMBER 1960

PUBLISHED BY THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD ST., MONTREAL 2, QUE., CANADA • TEL. VI. 2-5078

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Indexed in
The Engineering Index
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Meet the Authors

Arthur Porter, M.E.I.C., M.Sc. (Manchester '34), Ph.D., Dean of Engineering, The University of Saskatchewan, Saskatoon *(The Principles of Automatic Control).*

Dean Porter was an assistant lecturer in physics at the University of Manchester, England prior to attending M.I.T. as a Commonwealth Fellow in 1937. He was subsequently employed by the British Admiralty Research Laboratories, and then the Ministry of Supply. In 1946 Dean Porter joined the Royal Military College of Science, Shrivenham, England as Professor of Instrument Technology, and in 1949 he came to Toronto as head of the Research Division of Ferranti Electric. He later joined the staff of the Imperial College of Science & Technology and in 1958, the University of Saskatchewan.

Harold P. Klassen, M.E.I.C., B.Sc. Civil (Saskatchewan '49), Chief Municipal Engineer, Underwood McLellan & Associates Limited, Saskatoon *(Water Supply and Sewerage at Uranium City).*

After graduation Mr. Klassen joined his present firm as field engineer in charge of construction of utilities for the R.C.A.F. Station, Rivers, Manitoba. He later became an associate member of Underwood McLellan and Associates Ltd. and was appointed to their board of directors in 1959. Mr. Klassen is a member of the Association of Professional Engineers both in Manitoba and Saskatchewan.

John Convey, B.Sc. (Alberta) M.Sc., Ph.D., Director, Mines Branch, Department of Mines and Technical Surveys, Ottawa *(Mineral Resource Development in North and West).*

Dr. Convey served with the Scientific Research Department of the Royal Navy and spent six years in Sheffield laboratories in charge of metal physics. He returned to Canada in 1946 as associate professor at the University of Toronto. Two years later Dr. Convey joined the Mines Branch staff as Chief of the Physical Metallurgy Division. He has been the recipient of the C.I.M. Blaylock Medal for contributions in the development of atomic energy in Canada.

J. D. Mollard, M.E.I.C., B.Sc. Civil (Saskatchewan '45), M.Sc., Ph.D., President, J. D. Mollard and Associates Limited, Regina. **H. E. Dishaw,** M.E.I.C., B.Sc. Civil (Saskatchewan '51), Consulting Engineer, J. D. Mollard and Associates Limited, Regina *(Airphoto Interpretation in Municipal Engineering).*

Before setting up his own consulting practice Dr. Mollard was with the Saskatchewan Department of Highways as resident engineer and with the Prairie Farm Rehabilitation Association as air surveys engineer. He is a former councillor of the Association of Professional Engineers of Saskatchewan.

Until 1956 Mr. Dishaw was soils engineer and special projects engineer of the Materials Branch, Saskatchewan Department of Highways. He now specializes in airphoto interpretation as applied to preliminary engineering and engineering-geology investigations.

Thomas Lamb, M.E.I.C., B.Sc. Civil (Manitoba '41), President and Resident Partner, T. Lamb, McManus & Associates Ltd., Consulting Engineers, Calgary. **Ralph N. McManus,** M.E.I.C., B.Sc., Civil (Alberta '42), M.Sc., Ph.D., Principal, T. Lamb, McManus & Associates Ltd., Consulting Engineers, Calgary *(The Dunvegan Suspension Bridge).*

For eleven years Mr. Lamb was employed by the Highways Branch, Manitoba Department of Public Works. His positions there included Assistant Bridge Engineer, Assistant District Engineer, Executive Assistant to the Deputy Minister, and Bridge Engineer. He set up his consulting practice in 1952.

In 1956 Dr. McManus resigned from the University of Alberta, where he had served for 14 years, to devote full time to his consulting practice. Dr. McManus is also a principal of Structural Engineering Services Ltd. He is a member of the Association of Professional Engineers of Alberta.

H. N. G. Allen, M.A. (Cambridge '33), Joint Managing Director, W. H. Allen Sons & Company Ltd., Bedford, England. **T. P. Jones,** Chief Engineer and Manager, Gearing Department, W. H. Allen Sons & Company Ltd., Worcestershire, England. *(Marine and Industrial High Powered Epicyclic Gearing).*

Mr. Allen is a Member of Council and past chairman of the British Internal Combustion Engine Research Association; a Member of Council of the British Hydro-mechanics Research Association; a Governor of the College of Aeronautics, Cranfield; a Member of the British Transport Commission Research Advisory Council; and Vice-Chairman of the Council of Mander College, Bedford.

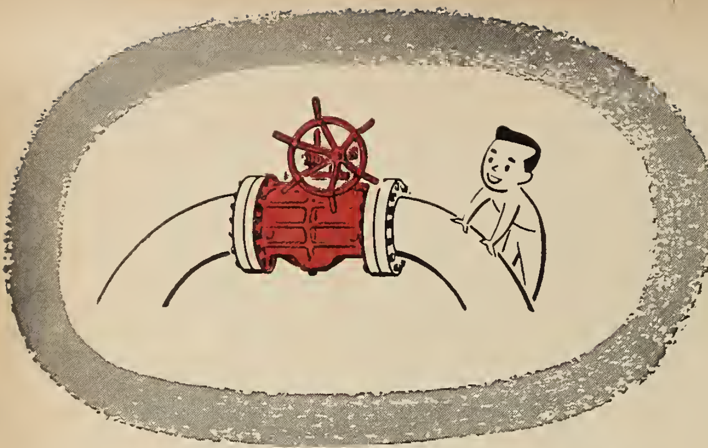
Mr. Jones received his general and technical education at Newport College, Monmouthshire, and after an apprenticeship with W. H. Allen Sons & Co., Ltd., and further technical study at Newcastle-upon-Tyne, was awarded a Higher National Certificate. He was subsequently engaged on the installation of Allen auxiliary machinery on both Naval and Mercantile vessels.

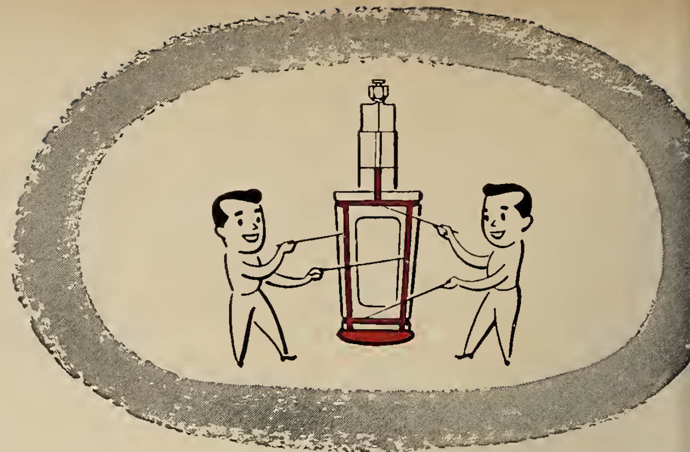
Lt. Col. Lyndall F. Urwick, B.A., (Oxford '13), M.A., Chairman of the Board, Urwick, Orr & Partners Limited, Management Consultants, London, England *(Management—Horse Trading or Trusteeship?).*

Colonel Urwick, a pioneer and authority in scientific management, is a well known lecturer and author in this field. From 1928-33 he was Director of the International Management Institute at Geneva. His positions in public service, both in Britain and internationally, have been extremely varied and include, among others: Colombo Plan advisor to the Indian Government; past-chairman of the Education Committee, Institute of Industrial Administration; and Director, American Management Association's Inquiry into Management Development.

COVER ILLUSTRATION

Automatic control, discussed by Dr. Arthur Porter in this issue, can invest machines with certain powers evident in man and associated with his capacity for thought. This type of brain function is demonstrated as the tennis player calculates the factors involved in the successful interception and return of the ball.

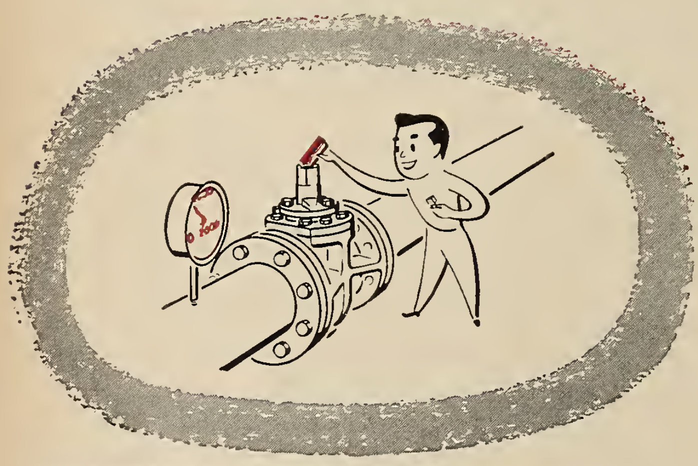


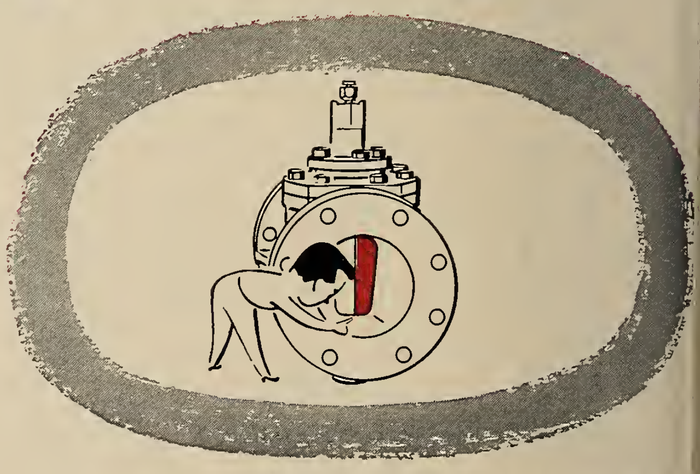


WHAT IS THE ADVANTAGE OF A LUBRICATED VALVE? —The most important advantage of a lubricated valve is that it *seals far tighter* than ordinary valves. The thin film of plastic lubricant forced into the ports of the plug is a pressure seal in itself. And the possibility of seizing or galling is eliminated because the plug can be hydraulically jacked for instant operation. Lubrication is also *preventive maintenance* against down time.

WHAT DOES THE LUBRICANT DO?—In a Rockwell-Nordstrom valve, lubricant is forced through grooves surrounding the plug ports where it acts as a *double seal* against leakage. By hydraulic action, lubricant under pressure also jacks up the plug keeping it free for *instant quarter-turn* operation. And lubrication means that operation is smooth and easy. Finally, lubricant prevents grinding wear for longer valve life at lowest cost.

DOES VALVE LUBRICATION ? ? ?





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THE PRINCIPLES OF AUTOMATIC CONTROL

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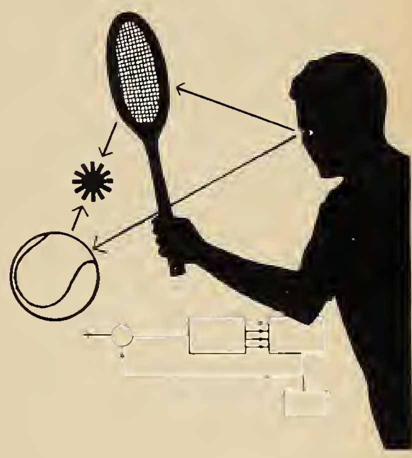
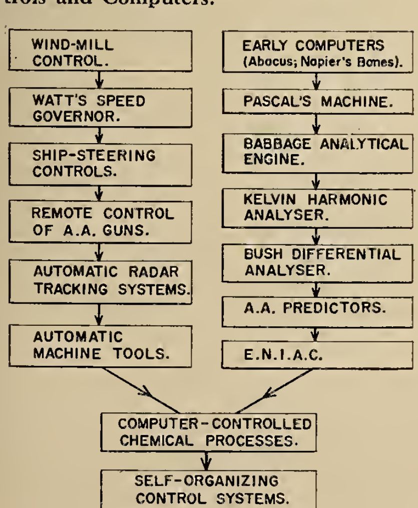


In common with all fields of applied science, control system technology has undergone a profound change during the past two decades. Some of the major influences have been the applications of analogue and digital computers, the increased reliability and efficiency of electronic components (e.g. semi-conductor devices), the evolution of a comprehensive theory of linear systems, and the recognition that certain classes of non-linear control systems can be designed scientifically. But perhaps the most significant development has been the formulation of control problems on the basis of system optimization. The object of this paper is to re-evaluate the basic principles of automatic control in the light of this trend. System optimization is synonymous essentially with the optimum utilization of information and the necessity for feedback processes in automatic control follows directly from this concept. On the other hand, simple first-order feedback loops are usually inadequate to optimize complex processes, and second-order and perhaps a hierarchy of control loops are required. This principle is illustrated by the evolutionary operational method introduced by Box. A further significant factor in the control of multi-variable processes is the optimal coding of information which may, in some cases, involve carrying out correlation analyses. Coding is an essential prerequisite for the basically important procedure referred to as information classification which, considered in terms of probability, leads to the concept of pattern recognition. And pattern recognition determines the degree of programmed, as opposed to plastic, control required for a specific process; the biological model provides important analogies in this connection. Some consideration is given in the paper to the associated problems of decision-taking and logical goal-seeking. The requirements of automatic controls based on the principle of self-organization (i.e. heuristic systems) are discussed briefly.

THE REMARKABLE advances in the theory and design of servomechanisms and automatic process controllers have had a considerable impact on all branches of applied science and technology during the past two decades. And there has been a growing realization that electronic computers and computer techniques have an important part to play in the future evolution of automatic control. Many first-class books, some of massive proportions, have been written on the subject recently, and it might appear impracticable for a single paper to give an adequate introduction to automatic control principles. On the other hand, the increasing importance of systems engineering is accenting the need for a re-evaluation of these principles. In particular, the goal of the systems engineer must essentially be to optimize the performance of a system. And if control, as such, is limited merely to the stabilization of a system with adequate speed of response, it usually will not embrace the concept of optimization. Moreover, it is well known that the impact of automatic control principles in such fields as economics, management, marketing research, etc., is already considerable, and these offshoots of servomechanism theory are already having an important influence on the basic philosophy of automatic control. And this is consistent with the whole feedback principle.

Fig. 1. The Evolution of Automatic Controls and Computers.



A brief review of the evolution of automatic control may be helpful. In the light of recent developments there are clearly two main branches, one concerned essentially with automatic control systems and the other with analogue and digital computer techniques, and recently these branches have coalesced. The major landmarks in the evolution of both branches are indicated in Fig. 1. Many notable names have been omitted from the diagram which is intended as a guide and not as a comprehensive genealogical tree.

It is notable that, although the branches of automatic control and automatic computation were complementary for many years, it remained for the designers of automatic fire control equipment, during World War II, to introduce the concept of the integrated design of systems involving both servomechanisms and complex automatic computers. These computers were essentially analogues which solved the geometry of the fire control problem. The complete systems were based on physical models, and they exemplified the important principle that the optimization of a process can often be facilitated by setting up models as controllers.

The process of optimization involves the optimum utilization of information, and it is not surprising that a recent trend in process control is the use of computers and data-processing equipment to achieve the desired goals. Thus, during the comparatively short span of twelve years both analogue and digital computers have been brought within the orbit of the control system engineer. And the present trend is for computers to be integrated into complex automatic control systems. While recognizing the high importance of these machines in the design of automatic controllers, this paper, being involved with basic principles rather than techniques, does not consider specific computer applications.

Computers are only capable of handling information which has been coded into "machine language", and as far as digital machines are concerned this involves a binary coding procedure. Several basic measuring instruments are at present being modified so that analogue outputs can be converted into digital outputs for communication and computational requirements. On the other hand, there appears to be some evidence that the evolution of automatic controllers will not be solely in the direction of digital control but rather that combinations of analogue and digital systems will be required.

Feedback

The fundamental characteristic of all control systems is feedback. Even in the cases of control systems which may be regarded as "open loop" systems there is necessarily, considering the system as a whole, some monitoring process involved. It is sometimes convenient, however, to consider the control system as a programmed control, cf. the programming of a digital computer. And the nature of a control system will normally be a compromise between fully-programmed and completely non-programmed depending upon the process under control. From the point of view of information theory, the more programming involved in a process, the more redundancy of information is implied and hence, the greater the degree of predictability.

It is convenient to consider the fundamental physical control processes* in which feedback is an essential feature. These processes shown schematically in Fig. 2 (a), (b) and (c) are:

(i) system protection;
(ii) system regulation;
(iii) system optimization.

Items (i) and (ii) may be integrated into a single over-all controller although it is convenient to consider them here as independent processes. In the case of protection systems the feedback only comes into action when certain plant conditions satisfy a set of logical rules or constraints which are designed to prevent accidents or damage in the operation of the plant. In this respect the plant protection system is analogous in the human nervous system to "pain" which can be regarded as a warning signal. The principles upon which protection systems are based reduce to the principles of logic and as such are beyond the scope of this paper.

*Note that feedback is a basic characteristic of the majority of biological mechanisms, of economics, of communications, etc.

Fig. 2 (b) shows a simple process regulating control in which it is required to keep two control variables p and q at the desired values p_0 and q_0. In practice many variables may be involved and the objective is to constrain these variables to depart as little as possible from their desired values in spite of internal and external disturbances. A considerable portion of the literature on automatic control is devoted to the theory of automatic process regulation.

The principle of optimization is illustrated in Fig. 2 (c). It is assumed that a regulation system is associated with each significant control variable, the object of which is to ensure that the commands of the "optimizing controller" are obeyed. It is assumed further that the criteria for optimum behaviour of the process have been adequately stated in symbolic form and that suitable instrumentation for measuring the optimizing variables is provided. As in protection and regulation processes, feedback is fundamental in all optimization procedures in order to handle unpredictable disturbances.

In addition to the three basic applications of feedback, considered above, the principle is also used to produce special transfer functions and to minimize the effect of certain nonlinearities. It is also used to modify impedances at certain points in network structures, and to provide control over the variation of parameters due to extraneous influences. But these applications are essentially manifestations of the fundamental idea that feedback is introduced to deal with unpredictable disturbances.

Prediction and Feedback

Information theory indicates that the more predictable a process the less information is available at a specific time. In the limit, for example, a process whose behaviour is fully predictable will not require monitoring feedback. Most processes by their nature are to some extent predictable, otherwise automatic control of the process would be impossible; they are in fact stochastic in nature. Three special techniques which illustrate the relationship between predictability and feedback are considered below.

In the systems described by Lang and Ham,[1] i.e. conditional feedback systems, and the system described by Reswick,[2] i.e. disturbance response feedback, the basic idea is to utilize all known information concerning the process and to build dynamic models

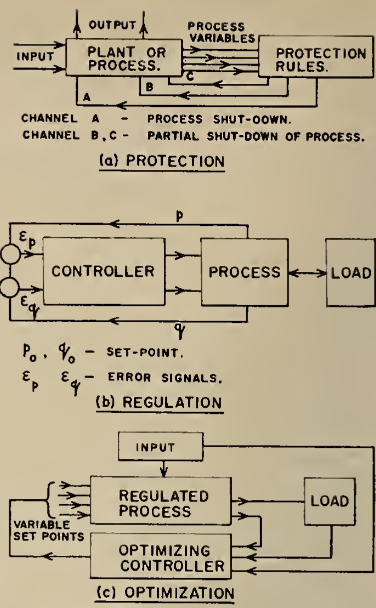


Fig. 2. Classes of Automatic Control Systems.

for use as "model-controllers". For example, in Fig. 3, which represents a simplified form of the Lang-Ham system, the transfer function of the model is designed to match the transfer function of the main servo loop (this assumes no control element is introduced into the portion of the loop marked X). Clearly, if M(s) is the transfer function of the model and KG(s) is the open-loop transfer function of the servo system, and if

$$M(s) = KG(s) \qquad (1)$$

then, assuming no disturbances are involved such as, for example, saturation of amplifiers and motor, it will be seen that the control signal is zero. Only when disturbances are present will the error signal be finite. Moreover, the forward gain of this class of system can be made extremely high because the anti-stabilizing effect of disturbances can be handled by a compensating network at X. Thus, the intelligent use of information in the design of servomechanisms leads to enhanced predictability which, in turn, minimizes the possibility of unstable behaviour.

The Reswick disturbance-response feedback technique also involves the concept of the model-controller, although in this case the technique is applicable to regulators while the previous method applies essentially to servo-mechanisms. The method is illustrated in Fig. 4 in which the controller has the transfer function,

$$\frac{\lambda(s)}{\epsilon(s)} = \frac{k_1}{1 - k_2KG(s)} \qquad (2)$$

The controller transfer function involves two variable parameters k_1

and k_2 and it is not difficult to show that the value of k_2 is determined by the requirement that the steady-state error in the system must be zero. This leaves a single parameter k_1 as the basic control parameter. In a later section a generalized version of the Reswick model-controller is used to introduce the principle of self-organization.

The third technique arises in the design of a basic class of sampled-data control systems, first described by Porter and Stoneman.[3] In this case information is utilized to predict continuously the behaviour of the controlled variable rather than, as in the previous two cases, to predict system transfer functions. The system is shown schematically in Fig. 5.

The basis of the method is a system for automatically generating polynomials, the output of which is compared at sampling instants with the corresponding input, and the error signal is used to modify the coefficients of the polynomial output function progressively. Clearly, this system must be inherently stable because the feelback loop is open most of the time. The system handles initial transient conditions by successively switching in additional terms of the polynomial. In principle, this system assumes that the behaviour of the controlled quantity in any automatic control system can be represented in terms of a sequence of overlapping polynomials of order three or four. Again, the system differs from conventional control systems in so far as the feedback loop is only open at sampling instants and operates to determine the effect of disturbances which may have occurred since the previous sampling point.

Evolutionary Operation

The previous examples of feedback have dealt with simple first-order feedback loops as exemplified by Fig. 2(b). In practice, multi-loop systems, which may involve a hierarchy of loops, are common and the process of optimizing such systems involves the correlation of a large amount of information and the taking of decisions concerning the best operating conditions for a process at a particular time. In these complex systems the all-embracing feedback is essentially the decision-taking loop which determines such parameters as process set-points.

Some of the most fundamental work on the optimization of chemical processes has been due to Box.[4] The method has been described as "evolutionary operation" on account of its close parallelism with the process of natural selection in the evolution of biological species.

Box considered comparatively simple processes and based his method essentially on the exploration and exploitation of response surfaces. He was concerned with the yield of a chemical process, which perhaps depended on the pressure and temperature at which the process was operated, and also on the concentration of various chemical reagents. The response surface can be obtained by plotting yield on a vertical scale against temperature, pressure, etc. as shown in Fig. 6. An important consequence of the Box method is the fact that it is not profitable to consider each variable at a time when deciding on optimum values, and the method depends on simultaneous variation of the key parameters in such a way that the yield tends to climb the slope of the contours.

At present the evolutionary operation procedure is carried out for the most part by a combination of man and machine. All the relevant information concerning the past history of a process is available to a small group of specialists and, on the basis of certain statistical analyses, (usually carried out by a digital computer), this group decides how most effectively to change the values of the control parameters in order to climb the slope on a line of steepest ascent.

It transpires that the nature of the calculations involved in investigations of this kind is that of operations involving linear algebra. And perhaps the most significant technique is the application of "linear programming"[5]. These procedures are admirably suited to the high-speed digital computer. It is probable in the future that all manual aspects of evolutionary operation will be eliminated and the whole optimization process will become automatic.

Mathematically, the optimization procedure, when handled in terms of evolutionary operation, reduces to the problem of maximizing a linear function of control parameters which are subject to constraints which usually involve given inequalities. For example, one such inequality would arise from the fact that the temperature at which a given reaction must be carried out must in no circumstances exceed a stated value.

Coding and Classification of Information

Note on Information Theory: An important recent development has been the growth of information theory based on the classical work of Shannon[6] and Wiener.[7] Although at first sight information theory, which provides a scientific measure for certain basic types of information, is applicable for the most part to communication systems, there is little doubt that its impact on automatic control theory will be profound. The relationship between communication channel capacity, transmitter power, signal to noise ratio and bandwidth is particularly significant and has led, during the past few years, to new and more scientific methods of specifying the behaviour of control systems in terms of information handling capacity. But it is in the fundamental approach to the problem of coding information that the impact of information theory on automatic control is likely to be appreciable in the future. In this respect the optimal coding procedures of Shannon[8] and Huffman[9] are significant, not only in treating automatic control systems as communications channels, but also as means of reducing redundancy to an absolute minimum, bearing in mind the fact that a certain degree of redundancy is essential for error-free operation.

Nor should the physical process of coding be considered solely as the quantization of information, e.g., binary coding, etc., because, fundamentally, coding implies translating information into another language. And, since many data-handling processes can still be carried out most effectively by analogue methods, it is important not to neglect these in the study of control optimization procedures. For example, one of the most important methods available for analysing data is through correlation techniques, and these can usually be carried out much more effectively when the data is in analogue form rather than binary-coded form. The following section summarizes the importance of correlation processes in the synthesis of transfer functions of processes, and illustrates how information can be most effectively used in certain circumstances.

Correlation as a Coding Technique: For a simple linear control system, the output function for any bounded input function can be expressed as

$$\theta_0(t) = \int_0^t w(\tau)\theta_i(t-\tau)d\tau \qquad (3)$$

where $w(\tau)$ is the weighting function of the linear system.

Alternatively, it is sometimes convenient to regard the input and output functions of time as a time sequence of values, (with period T) in this case the above relationship is written,

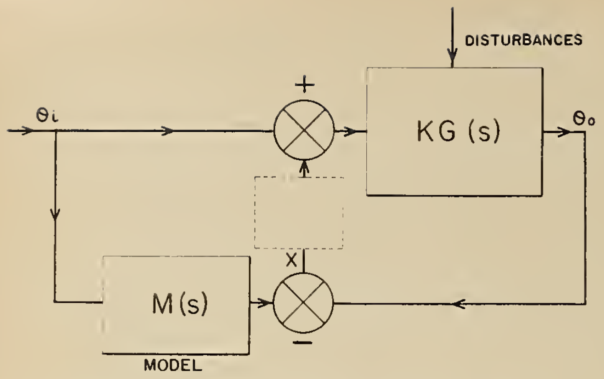


Fig. 3. Lang-Ham Conditional Feedback System.

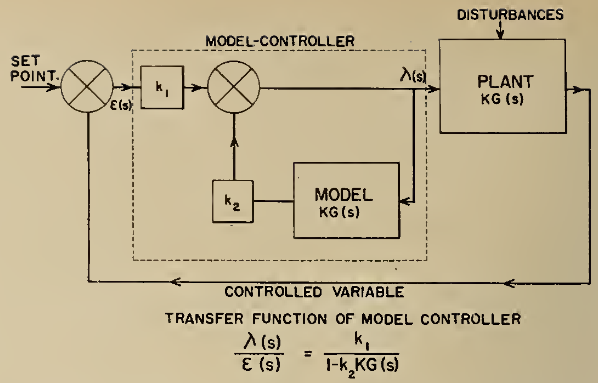


Fig. 4. Reswick Disturbance-Response Feedback.

$$\theta_0(t) = \sum_{n=0}^{k} w_n \theta_i(t-nT) \qquad (4)$$

Frequently the input and output functions are given in sampled-data form and it is required to determine the corresponding weighting function $w(\tau)$ of the linear process. Goodman and Reswick[10] have devised a so-called "delay-line synthesiser" to determine weighting functions in such cases. However, the major difficulty is to deal with the effect of extraneous disturbances which make prohibitive the determination of realistic weighting functions in the majority of cases. To overcome this difficulty it can be shown that if*

$$A_{ii}(\tau) = \overline{\theta_i(t) \cdot \theta_i(t+\tau)} \qquad (5)$$

is the auto correlation function of the input quantity θ_i(t), and

$$C_{i0}(\tau) = \overline{\theta_i(t) \cdot \theta_0(t+\tau)} \qquad (6)$$

is the cross-correlation function of θ_i(t) with θ_0(t), then,

$$C_{i0}(\tau) = \sum_{n=0}^{k} w_n \cdot A_{ii}(\tau-nT) \quad (7)$$

And this relationship can be used to determine w_n given A_{ii} and C_{io}, whereas the application of (4) directly is impractical. The significant point is that when the system output is perturbed by noise, which is not caused by the input, and hence not correlated with it, this noise is not included in the cross-correlation function. In fact, the correlation processes have effectively acted as an information filter and removed much extraneous information. Moreover, apart from the contributions of noise, all the statistical information contained in the time functions is still available in the auto and cross-correlation functions.

The above process illustrates a most significant trend in the development of automatic control systems. In order to predict system behaviour, a prerequisite of effective automatic control, it is necessary to disregard, as much as possible, all random and near-random information such as that introduced by noise. And correlation procedures are highly effective for this purpose. In the present context analogue correlation analyses may be described as coding processes.

Pattern Recognition: The requirement, in automatic control, that the process should be predictable to some degree is almost synonymous with the requirement that the system should incorporate a pattern recognition capability. In straightforward cases such as simple single-loop servomechanisms the pattern is inherent in the design of the system. For example, the ability of the system to determine the "direction and distance to go", and to recognize relative rates of change of θ_i(t) and θ_o(t) constitute properties which may be described as pattern recognition properties. But in more complex systems the patterns of behaviour are usually more obscure and it is necessary to explore all the information available in order to determine them. In some systems correlation procedures help considerably to minimize the deleterious effects of extraneous and irrelevant information,[11] and the application of elementary probability theory is of fundamental importance.

Pattern recognition necessarily involves the classification of information, and for simplicity it is convenient to consider control variables which are two-valued—i.e. the temperature (or pressure) is high or low. Following the work of Uttley,[12] and considering four binary variables A, B, C, D, a classification based on the conjunctions of the variables is shown in Fig. 7. The binary variables may be regarded as states, and it is required to classify these states over a given period of time during which it is assumed that the system is subject to dynamic modifications. Classification in this simple example is concerned essentially with "spatial" classification as opposed to "temporal". Each conjunction unit AB; BC; etc., is considered to incorporate a counter so that in the course of time the coincidences between state combinations can be determined and a "weighing factor" for each conjunction established. And the "value" of any conjunction unit will change continually with time if there is a high degree of randomness involved in the process on the one hand, and will reach a steady-state value if there is a high degree of redundancy on the other. In effect patterns of behaviour have been established based essentially on a spatial distribution of states—perhaps this simple classification process can be regarded as an elementary exercise in topology.

In some processes relationships between present and previous states are important. For example, in Fig. 8, although only one variable is involved, the significant factor is the temporal pattern of behaviour of this variable. The classification process relates to the present state, say A, to the three previous states, A^1, A^{11} and A^{111} — the *delta* symbols in Fig. 8 correspond to unit delays which may be regarded as short-term memories.

If n delay units are involved, with the corresponding circuits and conjunction units, the system is capable of handling patterns involving the previous (n-1) states. The process is essentially an auto-correlation process. Spatial-temporal patterns may be obtained using a combination of the systems shown in Figs. 7 and 8.

The type of patterns arising out of such classification procedures may be

*In equations (5) and (6) the bar indicates "average value".

regarded as probability patterns. And it is possible to represent them in terms of transition matrices, assuming that, in general, these matrices will change with time, and, in most practical systems, except those of a very simple kind, a steady-state will never be reached. But most processes can be described as ergodic, in so far as the variations in patterns occur over comparatively long periods of time compared with, for example, the time constants of the system.

Conditional Probability Considerations: The binary classification process introduced in the previous section has been utilized by Uttley[13] in the design of a conditional probability computer. This machine incorporates 32 conjunction units capable of handling 5 binary values. And a duplicate set of units is available which indicates conditionally the probability that the system will behave in a prescribed manner in the future. The coincidence units not only count conjunctions but also incorporate the characteristic of weighting information in such a way as to give recent events great weight and past events less weight on an exponential scale. Accordingly, the "strength" of a particular unit decrease exponentially with time unless it is stimulated externally—i.e. the unit possesses the property of "forgetting".

The conditional probability of two events A and B occurring together, given that A occurs is written as $P(AB/A) = P(B/A)$* and if this corresponds to a probability $>\frac{1}{2}$, the unit AB is excited when A alone is stimulated.

This class of machine has the property of prediction based on probability, and has in fact been applied by Uttley and Russell[14] to the control of simple processes. It has been demonstrated, moreover, that conditional probability machines have a learning capability which is closely parallel to simple biological learning processes. Thus, it has been shown that automatic control systems based on the conditional probability principle have the capability of learning from past experiences[15] although at the present stage of development this learning capability is almost trivial. It should be noted, however, that the classical experiments of Pavlov[16] on conditioned reflexes in dogs can be simulated using a simple conditional probability computer.

*The conditional probability of B given A is defined as

$$p(B/A) = \frac{p(A \text{ and } B)}{p(A)}$$

provided that $p(A) \neq 0$.

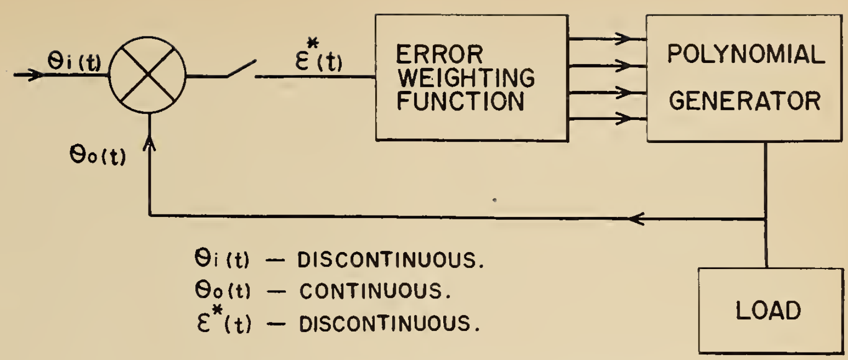


Fig. 5. A Sampled-Data Control System.

A basic limitation of conditional probability machines is their impracticability when the number of variables involved is greater than 6 or 7; for example, 20 variables would involve a total of more than 1 million coincidence units. It would be necessary, therefore, before applying this important principle to the control of complex processes, to introduce a pre-filtering unit which discards non-significant data. This presupposes that methods are at present available for carrying out this information filtering economically—unfortunately no satisfactory method has yet been devised, although the human nervous system handles the problem very effectively. A significant factor is that the more random the process, the more equipment will be required in order to establish probability patterns, and this implies that the complex processes in which we are interested must involve much redundant information.

The conditional probability approach to the problem of control can accordingly be applied to comparatively redundant stochastic processes, and fortunately, in practice most processes would appear to fall into this category. And this implies that the patterns of behaviour of these systems can be determined by such techniques as correlation and conditional probability and these in turn will provide the basis for process optimization.

Note on Decision-taking and Logical Goal-seeking

The feedback property in a system implies decision-taking. And it may not be out of place to examine briefly the role of decision-taking in automatic control. In simple servomechanisms the comparator unit can be regarded as a decision-taking unit and the rules upon which decisions are based are both simple and concise. Further, the inherent goal-seeking nature of simple servomechanisms is obvious. But in multi-variable processes it may be impossible to define the overall control problem in terms of simple decision-elements and the adequate specification of the goals may not be straightforward.

Decision-taking implies the existence of given rules of behaviour and, in order to be meaningful, these must be stated in logical form. For example, if the system variables are binary in nature, the rules may be stated in terms of two-valued logic, while, on the other hand, if many-valued variables are involved, it may be necessary to formulate the rules in terms of many-valued logics.[17]

Again, the basic nature of the rules is not likely to differ appreciably from that of the rules involved in the protection of a process, and certainly the same variables will be involved. But protection as such is a very crude form of control, and if process optimization is required more sophisticated rules must be formulated. Another important point is that if the rules of operation are stated completely, thereby leaving no room for probability and past history considerations, the automatic control of the process is essentially a deterministic operation in spite of the fact that the actual goal-seeking procedures may involve random search methods. Summing up, therefore, in order to carry out optimization procedures it is necessary to state certain basic operating rules, and to build these into the control system,* and, in addition, to provide the facility of taking into account the past history of the process. As a result a degree of indeterminancy will be introduced into the automatic control.

The mechanization of logical rules can be readily achieved,[18] and it is in this connection that electronic computer techniques will be of high im-

*This is an alternative way of saying that the goals must be specified and introduced into the system in a practical way. In a simple regulator the goal is to maintain a control variable at a given value — physically, the goal may be introduced into the system as a fixed voltage level.

portance in the future development of automatic control systems. The deterministic portion of the system will inevitably be "programmed" in much the same way as a digital computer is programmed to solve mathematical problems. Moreover, it has been demonstrated recently that topological patterns representing basic logical and arithmetical operations, can be converted directly into logical circuits and this sort of technique may have increasing importance in the control of processes.[19] It should also be noted that the term "process" in this connection can be interpreted in the widest possible sense. For example, processes such as the automatic control of air traffic; the scheduling of operations in a production line; the control of railway traffic and road traffic; the control of complex communications systems; etc., are included. Indeed, the majority of problems involving time-tabling can be stated in terms of logical connectives.

The Principle of Self-organization

Although feedback is recognized as the fundamental characteristic of automatic control systems, the principle of self-organization may be regarded as of almost comparable significance. For example, the majority of biological processes are self-organizing, otherwise life would be impossible. The concept of self-organization is associated with "plastic", as opposed to "programmed" behaviour, and as such it is of great importance in the optimization of processes. Elementary self-adapting systems have been known for several years, e.g. automatic gain control in radio receivers, but the broader implications of the idea have not been exploited in the optimization of control systems.

One generic class of self-organizing regulators is that proposed by Reswick[20] in connection with the application of the delay-line synthesiser as a model-controller in the automatic regulation of a process. Although this system is not intended as a practical proposal the basic idea is sufficiently important to justify special mention. The system is shown schematically in Fig. 9. To minimize the effects of noise introduced in the process the delay-line synthesiser operates on the auto-correlation function of the control variable $\theta_i(t)$ and the cross-correlation function of $\theta_i(t)$ with $\theta_0(t)$. An approximation of the equivalent weighting function of the process can then be obtained manually. However, in the hypothetical system shown in Fig. 9, automatic operation is assumed.

The key feature of the Reswick self-adapting regulator is the fact that the system takes into account the possibility of changes in the process weighting function with time. Undoubtedly, this system would give very accurate regulation although its complexity (assuming the weighting function is synthesized from 20 ordinates, 20 independent servomechanisms would be required in addition to the other equipment), would be prohibitive.

Several other classes of self-adapting regulators and servo-mechanisms have been investigated recently.[21] Such systems, of which the servo system incorporating automatic gain control is the most elementary, will find increasing applications in such problems as automatic machine tool control, the control of space vehicles, the control of aircraft control surfaces, etc. These classes of control systems involve environmental changes which cannot be handled by classical feedback techniques and in almost all cases it is necessary to modify automatically the controller transfer function as a function of the environment. It is not unlikely moreover, that the principle of self-organization will be utilized widely in all automatic control systems where high accuracy is required. But in general the principle of self-adaption as applied to single loop and to three and four variable control problems is not adequate to deal with the problem of process optimization.

The major limitations of such simple self-adapting systems are:

(i) Each control variable requires a separate control system and the problem of handling inter-action effects may be extremely difficult;

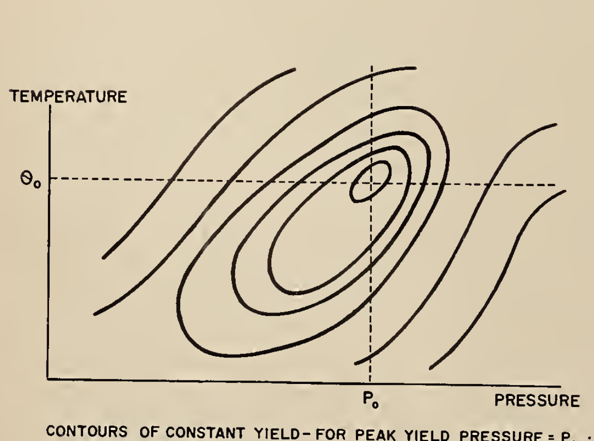
(ii) Although the internal loops of a process can be optimized by such methods as the Reswick self-adapting regulator, the same principle is not applicable to the optimization of the process as a whole. In other words, the major problem is the optimization of the outer loops which involve the difficult decision-taking requirements.

Further, in spite of the many successes of the process of evolutionary operation, it must be noted that the method is applicable essentially to processes involving no more than 3 or 4 key control variables. Additional control variables would so complicate the slope-climbing process, and would involve such large-scale computing facilities, that the effectiveness of the method as a process optimization procedure is limited. The method necessarily involves programmed techniques while the methods we seek must essentially be of a plastic character.

Requirements: The basic requirements of a fully automatic self-organizing process are:

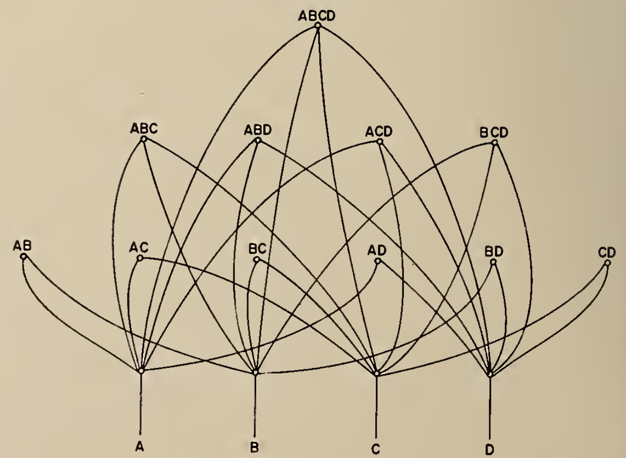
(i) An adequate statement of the process goals (i.e. the criteria of performance) and the means whereby these can be converted into machine language. This requirement may be

Fig. 6.



CONTOURS OF CONSTANT YIELD-FOR PEAK YIELD PRESSURE = P_0 ; TEMPERATURE = Θ_0.

Fig. 7. Spatial Classification of Four Bi-Valued Variables (after Uttley)



regarded as "specification of the rules of the game";

(ii) An inherent capability of adjusting key process variables in order to achieve the process goals in spite of continuously changing environmental conditions.

It has already been mentioned that although the statement and practical manifestation of the goal in simple servomechanisms and regulators is straightforward, the problem may be difficult in complex multi-variable processes. One reason is that goals may be incompatible e.g. the maximization of yield combined with the minimization of cost and customer satisfaction considerations. Further, unpredictable market conditions must, if possible, be taken into account, although this important aspect is likely to be handled by plant managers for several years to come. And, given the goals, there remains their interpretation into machine language. In this latter connection the language will almost certainly be that of (a) symbolic logic and (b) conditional probability. Thus, at a particular time, the goal and constraints may perhaps be expressed as in (8), where A, B, C . . .* are variables which describe the state of the process, and α, β, γ, δ . . . are values of set-points. The logical relationship (i) defines the goal and (ii), (iii), etc., process constraints based on past behaviour.

$$\text{(i)}\quad A \cdot B \cdot \overline{C} \cdot D \cdot \overline{E} \cdot \overline{F} \cdot G \cdot H$$

$$\text{(ii)}\quad p(A \cdot B \cdot C)/(\alpha \cdot \beta \cdot \gamma)] = 0.7$$

$$\text{(iii)}\quad p(\overline{C} \cdot D \cdot \overline{B} \cdot H)/(\alpha \cdot \delta \cdot \xi)] = 0.9 \qquad (8)$$

These rules are hypothetical but suggest nevertheless the general nature of the self-organizing problem — they imply basically that information must be stored, classified and conditional probability computations carried out. The mechanization of the rules corresponds to the motivation of the controller so that the system is always constrained to seek the goals. The latter may change from time to time and will be assigned by human operators. In biological processes the relationships between specified goals and the corresponding motivations are usually clearly defined and in simple cases may be reduced to such relationships as (8)—cf. the Pavlov experiments. However, in these cases the goals, usually complex functions of the environment, are established automatically.

*2-valued logic is assumed and standard symbols are used—however, there is no fundamental reason why the rules should not be stated in terms of many-valued logics. The classification process may involve not only conjunctions but also disjunctions (cf. rule (ii),), and other logical operations.

The fundamental nature of a self-organizing control system is illustrated in Fig. 10; the main operations are outlined briefly below. It should be stressed that this type of controller has not, except in simple cases, been built and tested. However, considerable theoretical work, including digital computer simulations, is in progress and there is little doubt that practical systems, based on these principles, will be available within a few years.

Learning Capability: All self-organizing systems must incorporate a learning capability which necessitates adequate storage of past behaviour.* In this context, learning is essentially learning through association, and this suggests that the controller must be conditioned in a similar way to the Pavlov dog. This learning, or conditioning process requires first, the classification of available information and second, the extrapolation of the inherent patterns in the information on the basis of conditional probability determinations. And in these terms the approximate future behaviour of a process can be predicted.

Consider the nature of the patterns which may be obtained during the operation of a simple process. Suppose the process can be regarded as a simple Markov chain process[22] having four states A, B, C, and D. The probability that state A will follow state D, or state A will follow state A etc. can be represented as a probability transition matrix i.e.

$$P = \begin{array}{c|cccc|} & A & B & C & D \\ A & P_{AA} & P_{AB} & P_{AC} & P_{AD} \\ B & P_{BA} & P_{BB} & P_{BC} & P_{BD} \\ C & P_{CA} & P_{CB} & P_{CC} & P_{CD} \\ D & P_{DA} & P_{DB} & P_{DC} & P_{DD} \end{array} \qquad (9)$$

If the process is ideally ergodic, a future state can be predicted on the basis of fixed probability laws. But normally the transition matrix will not reach a steady-state and prediction must be based on changing probability laws. For example, if the present state is C, the probability that the following states will be A, D, B is clearly,

$$P_{CADB} = P_{CA} \cdot P_{AD} \cdot P_{DB} \qquad (10)$$

* Since this article was written an important contribution to the field of mechanized learning has been published by Professor Dennis Gabor and his co-workers at Imperial College, London.[23] This paper describes a self-organizing system based on a learning process.

And patterns of behaviour in this form can readily be determined. Note that each row of (9) is a probability vector since the sum of the individual elements is unity.

Now consider the more general case of a process whose behaviour depends on many previous states, not one state as above, and in which spatial and temporal patterns are required. A convenient method of describing the past and present behaviour of such a process is in terms of conditional probability matrices. Suppose the state of the process is characterized by three bi-valued variables A, B, C, the matrices are,

$$P_1 = \begin{array}{c|ccc|} & A \cdot B & A \cdot C & B \cdot C \\ A & p(B/A) & p(C/A) & p(BC/A) \\ B & p(A/B) & p(AC/B) & p(C/B) \\ C & p(AB/C) & p(A/C) & p(B/C) \end{array} \qquad (11)$$

$$P_2 = \begin{array}{c|c|} & A \cdot B \cdot C \\ A & p(BC/A) \\ B & p(AC/B) \\ C & p(AB/C) \end{array} \qquad (12)$$

Note that the following simple relationships exist between conjoint and conditional probabilities.

$$\begin{aligned} p(A \cdot B) &= p(A) \cdot p(B/A) \\ &= p(B) \cdot p(A/B) \qquad (13) \\ p(A \cdot B/A) &= p(B/A) \end{aligned}$$

The above matrices supply the behaviour patterns of the process upon which prediction can be based, and they must be kept continuously up-to-date. Moreover, it is assumed as indicated in Fig. 10 that the information has been suitably weighted. Clearly, the determination of all conditional probabilities involved in a process with more than eight control variables is prohibitive. In practice, however, complex processes may involve many variables and the object of the data coder is to select, by weighting procedures, the key variables, and to keep continuous surveillance over the incoming information to ensure that significant data is not discarded. In this way, only "profitable" combinations of variables are involved in the conditional probability computations. This procedure can be considered as "concept forming" and it constitutes the outstanding problem to be solved in the development of self-organizing systems.

The noise generator: In Fig. 10, the unit described on the "random-

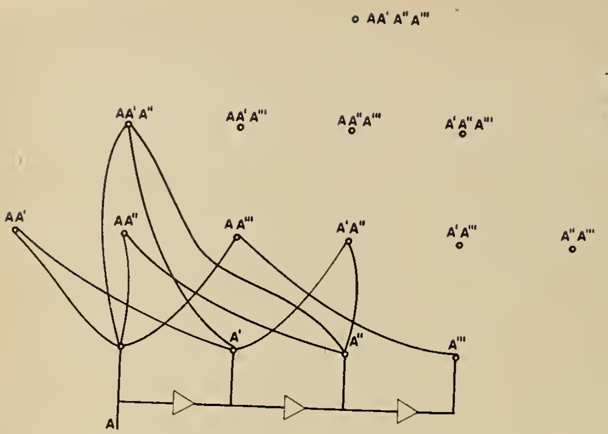
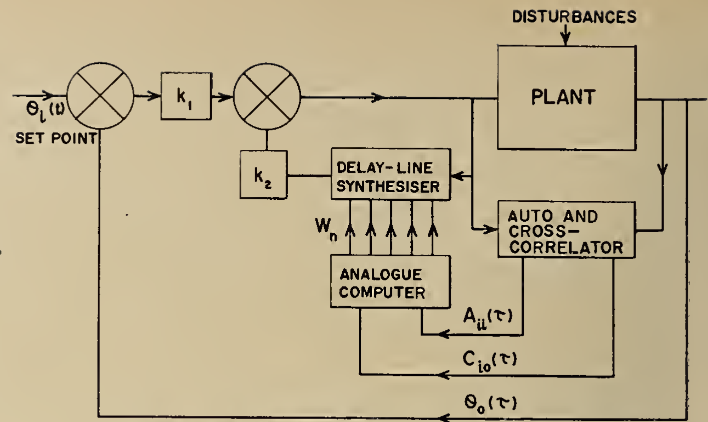


Fig. 8. Temporal Classification of a Bi-Valued Variables (after Uttley)



ANALOGUE COMPUTER DETERMINES W_n FROM THE RELATIONSHIP,

$$C_{io}(\tau) = \sum_{n=0}^{n=k} W_n A_{ii}(\tau - nT).$$

Fig. 9.

izer" needs explanation because it introduces an essential, and fundamental, characteristic of all self-organizing systems (both physical and biological). In seeking a goal a non-deterministic process must inevitably be guided by information obtained on a trial and error basis—the only basis upon which the "direction in which to go" can be determined.

For example, combinations of control parameters must be chosen to satisfy the optimization rules, but, since the environment is assumed to be dynamic and the rules are stated in probability terms, there is never a unique solution. It is necessary, therefore, to select a combination of parameters, on a random, or weighted average basis, from a given set of combinations which satisfy the requirements.

Another way of interpreting the randomizer requirement is to note that the environment is continuously changing in a partially random manner, and the optimum method of ensuring goal-directed behaviour, on the part of the process, is to search continuously for conditions which are most satisfactory. The only means available for achieving this objective is for the process to collect new information continuously about the present state and thereby to keep the patterns up-to-date. This suggests that a stochastic control process is required to handle a stochastic environment and accordingly a randomizer is a basic requirement.

There is already evidence that biological self-organizing processes incorporate noise generators and it can be concluded that feedback and noise generators are the fundamental requirements of all self-organizing systems. And this important new principle in automatic control engineering will no doubt facilitate the optimization of complex multi-variable control systems.

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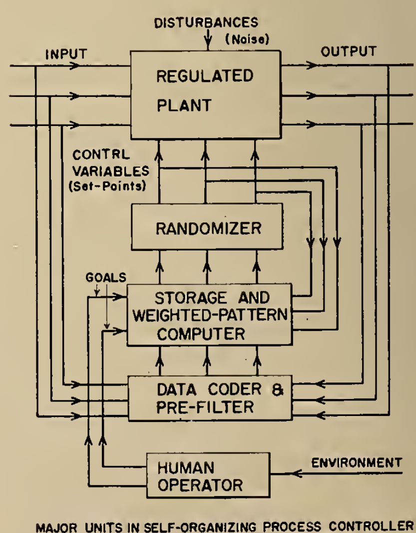
Fig. 10.



MAJOR UNITS IN SELF-ORGANIZING PROCESS CONTROLLER

WATER SUPPLY AND SEWERAGE AT URANIUM CITY

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

This paper deals with the design and construction problems encountered in providing a complete water and sewerage system in the precambrian regions of northern Saskatchewan. The unusual factors to be considered both in design and construction practices require both the engineers and contractors to be resourceful in their approach to the problems confronting them due to a lack of authentic data, transportation problems and climatic conditions.

The author has tried to present some of the problems and their solutions in such a manner that engineers who are presently engaged in northern development may benefit from these experiences.

URANIUM CITY, the hub of uranium mining operations in northern Saskatchewan, is a planned townsite on Martin Lake north of Lake Athabasca at approximately 59° 34′ north latitude and 108° 37′ west longitude. This is in the Precambrian Shield of Canada. As early as 1951 the growth and importance of the community was apparent and steps were taken by the Provincial Government to provide a well planned townsite with complete modern services comparable to those of any other community in Canada, thereby eliminating slums, shacktowns, etc. which usually accompany unorganized development. The Department of Natural Resources selected the site of Uranium City in 1951 and surveyed the property. In 1952 the Government of Saskatchewan requested the National Research Council to determine soil temperature conditions and the probable occurrence of permafrost. The work was undertaken by the National Research Council under the direction of Mr. R. F. Legget. A Progress Report[1] was issued by Mr. Legget in 1955 covering the Climate and Soil Conditions, permafrost and details of Soil Temperatures recorded during their investigation.

Access to the Uranium City area is unusual in that no road or railway exists within several hundred miles. Heavy bulk freight is shipped in by rail through Edmonton via the Northern Alberta Railways to Waterways on the Athabasca River. At Waterways the freight is transferred from the railway cars to barges. The barges are hauled by diesel tugs down the Athabasca River and across Lake Athabasca to a wharf at Bushell. A road connects Bushell with Uranium City and several uranium mines and mills in the district. All other transport services are by air from both Edmonton, Alberta and Prince Albert, Saskatchewan. Personnel are all transported in and out of the district by air as well as many thousands of tons of perishable goods and other urgent materials. It must be pointed out that the water transport season is very short, usually beginning in the first or second week of June and ending by mid-September.

The local geology is typical of the Precambrian geology of Canada. The topography consists of glaciated bedrock, giving a rolling terrain with depressions between rocky hills having glacial soils and muskeg in them. The country is well covered by jack pine, aspen and white birch and some spruce trees. The local soil in Uranium City is generally a clear sand and gravel mixture, with only a thin vegetal cover. Low-lying areas are often covered with thick layers of muskeg underlain with fine silts described best as "glacial rock flour".

Climatic conditions at Uranium City were not recorded but fortunately regular weather observations have been recorded for Fond Du Lac, 50 miles to the east, by the Meteorological Division, Department of Transport, since 1905.

In 1953 the Provincial Government requested a preliminary report on the possibilities of providing water and sewer services for this community. Preliminary surveys were carried out in the fall of that year and a report on a possible system and its costs was submitted in January 1954. Due to the limited time available and the very limited information at hand, this report was of necessity incomplete but it outlined possible sources of water supply, methods of water distribution, sewage collection and disposal. Fortunately from the engineer's standpoint, no action was taken by the government until 1955. By this time the population of Uranium City had more than doubled and the need for a complete review of the project was evident. Early in 1956 the Municipal Corporation of Uranium City and District was incorporated and the newly formed corporation engaged the consulting engineers to design a water and sewerage system and to supervise its construction.

The data gathered by the National Research Council[1] was available by this time. This information resolved many of the problems relating to the temperature degree and variations in the soils in question. In his report, Mr. Legget points out that the soil temperature observations were limited in quantity so that definite conclusions about the soil temperature could not be reached. The report clearly shows that permafrost exists under muskeg cover and that temperatures in the sandy and gravel soils were well below freezing even at depths of 12 ft. The observations clearly indicated that the grain size of the soil affected the temperature penetration appreciably. This was illustrated in two separate observations, one in damp, uniform, compact sand, the other in dry sand and gravel. In the latter installation, the minimum winter temperatures at 6, 9 and 12 ft. were 24°F, 26°F and 29°F respectively, whereas at the former location readings of 31°F, 32°F and 37°F respectively, were recorded at depths of 8, 10 and 13 ft. It is also shown that the minimum soil temperatures at the 8 to 13 ft. depth are reached in April and May whereas minimum air temperatures of −40°F range were reached in January. From this data, a reconstructed soil temperature profile indicates that at depths exceeding 10 ft. the average minimum soil temperatures should be above freezing. Comparisons and studies were made on two pipe recirculation systems at Flin Flon, Manitoba and Yellowknife, N.W.T., as well as the single pipe recirculation system at Fairbanks, Alaska. The relative advantages and disadvantages were considered in the selection of the system at Uranium City.

Establishing Design Criteria

The water distribution system selected for Uranium City was a single pipe recirculating system. As mentioned previously, the Townsite was planned by the provincial Government and streets had been laid out along valleys between ridges of rock outcroppings. Differences in elevation were extensive, varying from a minimum of 30 ft. (above Martin Lake) to 260 ft. The layout adapted itself to the use of 3 separate loops and in this way pressures were held within reasonable limits throughout the system. Separating the town into these individual loops furthermore provided for shorter runs and more positive recirculation.

The design of a recirculation system must be based on sound engineering principles involving heat transfer between the water and the surrounding medium. It is, therefore, necessary to utilize the heat contained in the water and add additional heat as required to prevent freezing. Since water contains both specific heat and latent heat, it is possible to remove all the specific heat of the water above the freezing point before freezing in the mains occurs. By recirculating the water throughout the system from the source of heat addition to distribution and back again to the heat source, it is possible to prevent freezing by controlling the rate of recirculation and the amount of heat added. To determine the rate of recirculation and the heat required it is necessary to calculate the heat losses in each loop under foreseen conditions.

In calculating the heat losses from the water it is necessary to determine the factors affecting the heat loss. The factors considered were:

(a) Temperature of Water;

(b) Film coefficient between fluid and pipe;

(c) Conductivity of pipe material;

(d) Conductivity of soil surrounding the pipe;

(e) Temperature of soil surrounding the pipe;

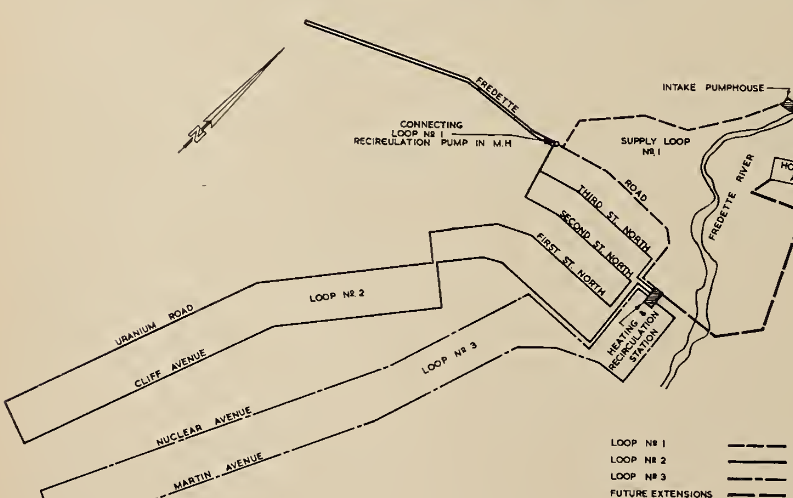
(f) Depth of bury;

(g) Conductivity of insulating materials.

The conductivity and temperature of the soil are probably the most important and most variable factors which require attention of the designer. Miles S. Kersten in his *Thermal Properties of Soils*[2] provides extensive information on the behaviour of temperature in soils. R. F. Legget and C. B. Crawford in *Soils Temperatures in Water Works Practice*[3] show the many factors influencing soil temperature. It is, therefore, necessary for the engineer to make several basic assumptions in order to complete his analysis.

In our design, the raw water was assumed to reach an average low temperature of 34°F. From Kersten[2], the thermal conductivity of the average soil was taken as 12 B.t.u. per hr. per sq. ft. per inch thickness and the mean air temperature of −35°F during the month of January was assumed to be equivalent to a soil temperature of 30°F at a depth of 9 ft. In a recirculation system it is our practice to use average values instead of maximum values for the factors affecting the operation of the system, that is, since the ground temperatures lag behind the air temperature from 2 to 3 months water temperatures may be

Fig. 1. Method of Looping Water Mains



increasing by the time minimum temperatures exist outside the pipes. Furthermore, although a 9 ft. bury is specified, except in rock, this is considered as the minimum depth and in many instances the depth will be greater so that the average minimum temperatures at the pipe will be increasingly warmer.

Having established these basic design criteria a minimum recirculation rate and heat requirements were calculated for each recirculation loop using both the minimum demand and the maximum demand which would occur during a fire. Since the separate loop system eliminated nearly all parallel lines and cross connections, calculations on flows were made by the Hardy Cross Method.

The demand for water and the ultimate extent of the system was based on existing population forecasts which indicated a growth to 6,000 persons when the peak capacity of uranium production would be developed. The Townsite had been planned accordingly. Should growth and development exceed the forecast, it would in all probability take place in other directions or in other areas.

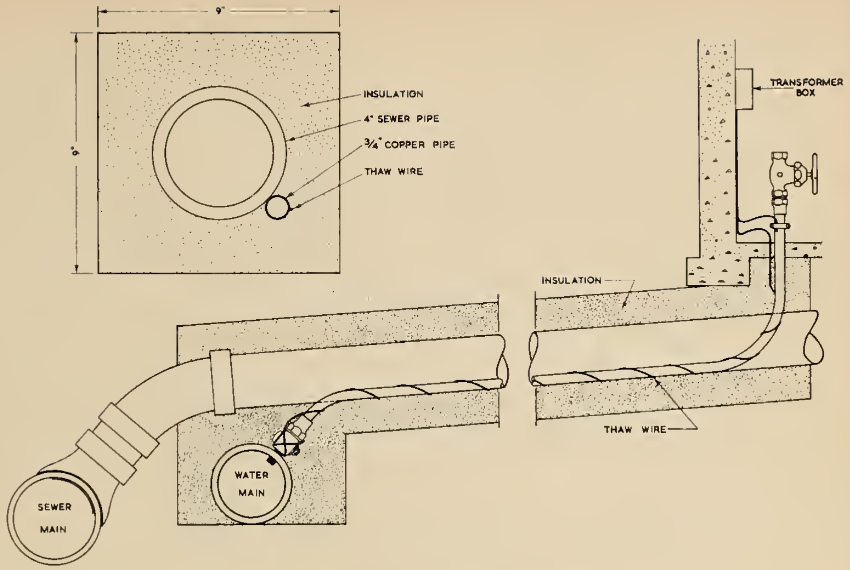


Fig. 2. Building Service Connection

Description of Water Supply and Distribution System

The water supply selected originates with Fredette Lake located approximately 3 miles north of the townsite and approximately 250 ft. higher than Martin Lake. The Fredette River connects Fredette Lake to Martin Lake and passes through the east part of the townsite. Consideration was given to constructing a pipeline to Fredette Lake but in view of the high cost, it was decided to take the water directly from the river just north of the townsite.

Twin intakes were constructed at a point on the Fredette River where a natural rock formation had created a pool approximately 6 ft. deep. A pumphouse equipped with both electric driven pumps and gasoline driven standby units was constructed and a 10 in. supply main 4,200 ft. long was built to the heating and recirculation station located in the townsite. The supply main was located so that it would also service property along most of its length. Future plans allow for completion of a recirculation loop through an area which will be developed for residential purposes if the growth continues. At the time of construction, provision was made to bleed water from the supply main and waste to the Fredette River at the heating and recirculation station since no heat was being added at the source.

The heating and recirculation site was selected so that separate loops could be laid out without excessive duplication of mains. Two distribution loops have been constructed in addition to the supply main. The pipe is 6 and 8 in. diam. spun cast-iron of the mechanical joint type. Each loop is provided with a recirculation pump and heat exchanger. The pumps have been sized so that the temperature differential can be maintained at a maximum drop of 5°F. Heat is provided by two 40 b.h.p. boilers which are equipped to burn Bunker "C" type fuel.

It is pointed out here that the recirculation pumps provide only the minimum circulation requirements. The make-up water is supplied from pumps at the Intake Pumphouse which were selected to meet the minimum and maximum domestic consumption, and the maximum fire demand. One distinct advantage in the single pipe recirculation system is that in the event of fire, water can be delivered through both the feed and return mains and this results in smaller pipe sizes to meet the fire demand.

Construction and Installation

The design of the system was completed during 1956. Due to the transportation problem and since it was desired to begin construction as early as possible in 1957, much of the material was purchased in 1956 and shipped to Uranium City during shipping season.

A contract was awarded in May of 1957 the work proceeded on schedule until freeze-up. The work had been prepared in two stages to be completed in 1957 and 1958.

The first stage consisted of the construction of all buildings and installation of the equipment, construction of the intakes, water supply main, trunk sewer and outfall and the water distribution mains and collecting sewers for the central area of the townsite. The second stage, completed in 1958, consisted of extension of the distribution and collection system for the remaining built-up areas.

The intake pumphouse has a reinforced concrete wet well approximately 20 ft. deep which is filled by gravity through two 12 in cast-iron intake pipes, from the river. Excavation was mainly solid rock which had to be blasted. The superstructure is of woodframe construction with an exterior finish of asbestos cement clapboard and Trafford Tile. The equipment consists of 3 vertical turbine pumps electrically driven. The 2 service pumps are rated at 150 g.p.m. and 300 g.p.m. The fire pump is rated at 1,200 g.p.m. and is equipped with an auxiliary gasoline engine. A chlorinator has been provided for water treatment.

The Heating and Recirculation building covers an area of 2,075 sq. ft. and houses 2-40 b.h.p. boilers, heat exchangers and recirculation pumps. Adequate office space for the operator and a workshop have been provided. Reinforced concrete was used to construct the foundations and piping chamber. The superstructure is wood frame construction with a cement-asbestos clapboard exterior finish. Asbestos flexboard interior finish was used to provide a fire resistant and serviceable structure. Materials which were readily available were selected so that the contracts should not be held up for lack of supply.

The Cutting and Metering station was constructed of materials similar to the others. This building holds a bar-screen, barminutor and a Parshall-flume for measuring the sewage. Adequate room has been provided for further chlorination equipment if and when it is required.

Soil conditions were such that very few unusual problems were encountered during the installation of the water and sewer mains. As previously outlined, much of the overburden was granular material with the result that most of the trenching was not costly. Due to the granular condition, water and sewer mains were laid in common trench. Where gravel or rock was encountered, sand backfill was placed around and over the pipe before backfilling with the excavated material. Where rock was encountered along the line of the trench, the outcrop was exposed in preparation for drilling and blasting. Where the trenches were less than 12 ft. deep, the trench was completely backfilled before detonating the charge and then re-excavated. In places where the rock was encountered at depths greater than 12 ft., only sufficient backfill was replaced, before blasting, to prevent damage to adjacent property. The blasted rock and fill material was then removed by a clamshell bucket.

The most difficult trenching was encountered in the installation of the trunk sewer which passed through a low lying area partially covered by muskeg. Permafrost occurred under this cover. The muskeg cover was stripped off in the spring and the permafrost was allowed to thaw out. This made it virtually impossible to bring in the excavating equipment until late in the season when the surface had frozen over. No special effort was made to insulate the pipe from the natural material except to provide a granular bed under and around the pipe. Some difficulty has been experienced with this line in that silt has entered and blocked the flow, but this has not been particularly due to the materials and methods prescribed but rather to insufficient care in making the joints watertight. Some cracking of manholes, which were constructed of concrete block, also has permitted the silt to enter the sewer. From observations to date, indications are that granular bedding and backfill would prevent misalignment if placed with due care. This project has also shown, however, that materials must be selected for ease in assembly to prevent unsatisfactory workmanship.

The water mains were installed without incident.

Since the townsite was laid out between rock ridges and the greater part of the system was buried to a depth of 9 ft. in sandy materials, rock excavation could not be avoided entirely. As is typical of the Precambrian Shield, rock outcroppings were encountered frequently. Where this occurred, it was not always considered economical to bury pipes as described. In this case, it was necessary that earth cover be replaced by insulation. For this purpose we selected a product which has been used extensively in the Fairbanks system. It consists of a mixture of vermiculite and asphalt which is readily applied in the field. It is economical and has sufficient insulating qualities for this application. The thickness of application was dependent upon the depth of bury. Pipes on or near the surface were given protection to external loads by constructing a wooden box around the pipe.

Description of Building Services

Probably the greatest difference in the Uranium City system from standard systems and others constructed in arctic regions was the method used to protect the building service connection. We have called this method a "Heat Storage System". In two pipe recirculating systems as well as in some one pipe systems the water service connection has consisted of two pipes and recirculation was provided to keep the lines from freezing. In two pipe systems the rate of flow was controlled by orifices placed in the line. These orifices are known to have plugged frequently and if recirculation is decreased appreciably, entire sections of a system may freeze up. At Fairbanks double service lines were used and pitorifices used to set up sufficient differential to cause circulation.[5] This requires velocities approaching 3 f.p.s. and increases the pumping costs. The heat storage method is a standard service connection which has been insulated and has an external heating device. In this case, the water pipe was wrapped with an electrical wire fastened at the main stop and taken into the building. The pipe was then firmly taped to the sewer pipe and the whole insulated The cost of the electrical wire was only 1½c per ft. and it was estimated that an average service line would only require 30 to 60 w. of energy which is taken from the household by means of an inexpensive transformer.

To place the insulation, two outside forms were placed along the desired grade and alignment of the service connection. A 3 in. layer of insulation was placed in the bottom of the form. The sewer pipe was then placed on the insulation and the water pipe, wrapped with the thaw wire, was placed adjacent to the sewer pipe and secured. Insulation was then packed around the pipes to the top of the forms which were removed when the insulation had cooled sufficiently so that the insulation did not adhere to them. This was followed by mopping the top and sides of the insulation with a hot asphalt coating to prevent water absorption.

Operation

The system has now been operating for two full years. An analysis of the first year's operation shows that the design criteria used have been reasonable. It has been fairly well established that heating is required from approximately December 1st to the beginning of May with recirculation commencing about two weeks earlier and stopping early in June when the raw water temperatures reach 40°F. Records show that the raw water temperature reaches 34°F in November, 33°F in January through to March, and in April and May an average 34°F again is reached. In June when the break up occurs, temperatures rise rapidly, reaching a maximum of 60°F by the end of July.

A considerable number of service freeze-ups were experienced during the first full winter's operation but by far the majority were due to the neglect on the part of the owners to connect the electrical protection wire in time or at all. This was no doubt due to a lack of familiarity with the system. Where repetitions occurred, it was noted that the pipes were entirely unprotected within the building. This situation is rapidly being corrected and satisfactory operation is almost ensured. The electrical wire makes thawing in case of freeze-up a very simple operation although the current applied must be limited to prevent damaging the wire permanently.

During the first year of operation, a gross fuel consumption of 6,000 gal. of oil was recorded. It is estimated that approximately 1,000 gal. were used for heating the structure and that 5,000 gal. were used up for heating the water. This represents a cost of $1,000 to heat approximately 7,500,000 gal. of water or 13c per thousand. Recirculation and heating both were started on December 18th and heating was discontinued on June 6th and recirculation stopped June 13th. It is noted here that during the first year of operation, only 125 services were in use. This has

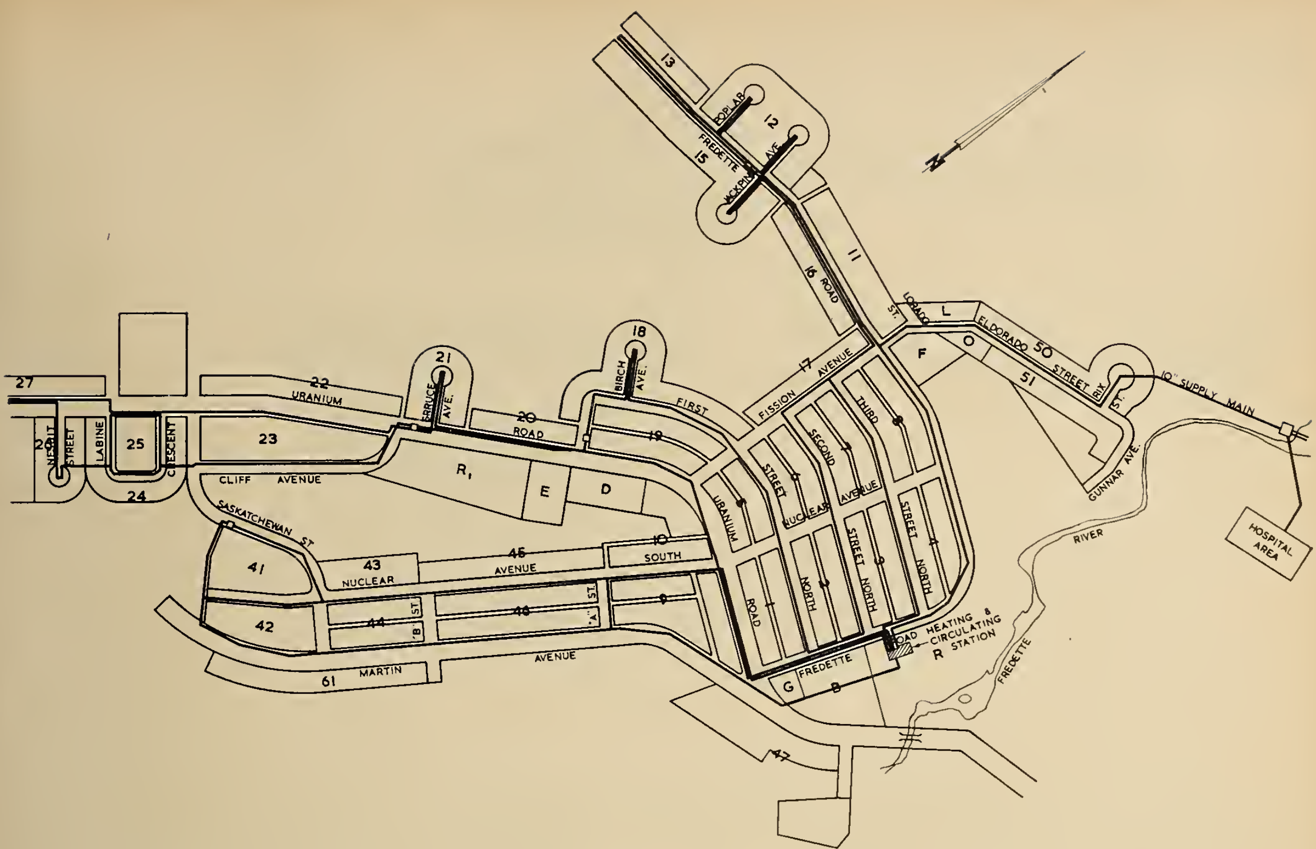


Fig. 3. Distribution System

now increased to approximately 350. It is felt that with the increased consumption, recirculation only will be required for a longer period in the early winter as well as in spring after the raw water temperatures begin to rise.

The following data will indicate the extent of the project and the costs of a water system for arctic regions. The total length of water mains installed was 38,500 ft. consisting of 4, 6, 8 and 10 in. cast-iron pipe. 3,800 cu. ft. of insulation was used on these water mains, 7.850 bd. ft. of lumber was used for boxing and 2,940 cu. yd. of rock was excavated. In addition, there were 32,875 ft. of 8, 10, 12 and 15 in. sewer main and over 300 service connections. The total cost of the project including structures, equipment and pipelines was approximately $1,123,000 including engineering costs. The average cost per foot for water mains was $11.20 and for sewer mains was $12.80. We feel that these costs show that arctic regions can be served at reasonable costs and that with improved materials and transportation facilities future costs will be less.

In conclusion, the Uranium City water system provides a positive circulation of water and the control affords minimum heat addition without waste. House services are economical and well protected against freezing, and the danger of plugging and contamination factors has been minimized if not eliminated. In this system we have eliminated the disadvantages of the two pipe recirculation principle, that is, short circuiting circulation and the double pipe installation. We have used the advantages of one pipe recirculation and eliminated the high pumping costs necessary to provide circulation in house service connections. Two disadvantages that the householder must be relied upon to assure protection of service lines and that there is some inflexibility for extension or revision to the system. Since this system has been in operation a similar system has been designed and installed at Thompson, Manitoba, for the International Nickel Company of Canada, with modifications and improvements. At present, two other installations of this type are at the design stage and it is apparent that northern Canada can be developed and provided with the modern facilities so vital to the personnel who are going to settle there with their families and make it their home.

Acknowledgements

The information presented in this paper represents the results of a large amount of work by other members of our organization and the author is indebted to them for much of the information. We wish to express our thanks to Mr. G. J. Darychuk, Manager of the Municipal Corporation of Uranium City and District and the members of Council for their kind permission to present this paper and for the co-operation they have shown in providing records of the operations.

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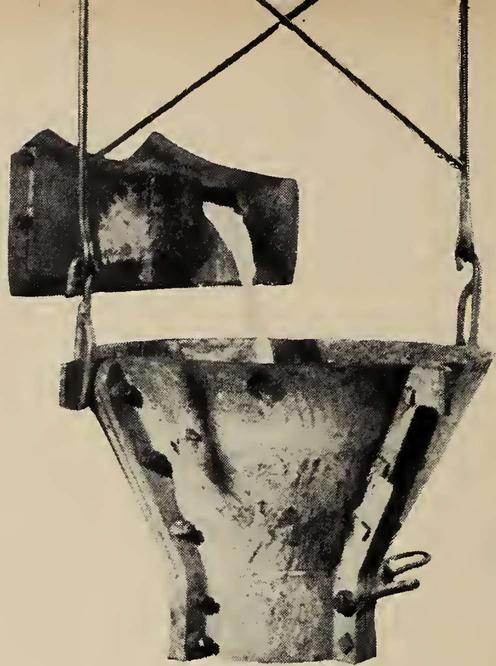
MINERAL RESOURCE DEVELOPMENT IN NORTH AND WEST



John Convey,
Director, Mines Branch,
Department of Mines and Technical Surveys,
Ottawa.

In man's everlasting struggle to control and improve his environment, engineers and scientists contribute more to the success of this struggle than any other group of men. An engineer, we are told, is an applied scientist who makes use of knowledge supplied by science and by applying this knowledge to the forces and materials of nature, he has created a very comfortable place for humans to live.

THE DEVELOPMENT of Canada has been a colossal undertaking in engineering; first, there has been the problem of communications, the spanning of the continent by telegraph and telephone and lately a multi-channel micro-wave system. Then there have been the problems of transportation, the building of two trans-Canada railway systems, a transcontinental highway, and an inland water route up the St. Lawrence into the heart of the continent. The development of our forests, minerals and water power resources has called on the skills of the structural engineer, the mining engineer and the metallurgical engineer. These people have built our hydro stations, sometimes in remote parts of the country such as at Reindeer Lake in Saskatchewan and have shown how our mineral wealth can be extracted from solid rock at reasonable costs and converted into concentrates and finished products. Mechanical engineers have improved machinery so that one can do easily the work which formerly was difficult for many, making our industries and our farms efficient to a point unimaginable to our fore-fathers. More recently chemical and petroleum engineers have played essential parts in our growing petroleum and petrochemical industries, and most recently of all, electronics engineers are promising us automatic factories operating twenty-four hours a day seven days a week producing a stream of products while a few maintenance men look on.

However, Canada is a large and often difficult country and many areas are still either frontier areas or nearly so. Historically Canada was opened up by the fur traders, whose exploratory activities have been consolidated by the miners and by the farmers and ranchers.

With the increasing complexity of modern technology, engineers like other professional people have had to specialize. I would like to discuss with you now the accomplishments of a dedicated group of scientists and engineers who are specialists and compose the Mines Branch at Ottawa.

Deposits of metal ores, industrial minerals and fossil fuels are of little use in the ground. After discovery these resources must be developed into economic feed materials for Canadian industry. This has been the prime function of the Mines Branch since its founding in 1907.

The Mines Branch embraces five Divisions: Mineral Processing; Extraction Metallurgy; Mineral Sciences; Fuels and Mining Practice; and Physical Metallurgy.

The known mineral resources of an area that comprises about two-thirds of Canada, from the Canada-U.S. border to the Arctic and from Winnipeg to the Pacific, have at one time or another come under the scrutiny of the engineers and scientists of the above mentioned Divisions.

Since a very large proportion of the mineral resources of Western Canada is represented by fossil fuels it may be appropriate to emphasize the work done by the Mines Branch on fuels.

During the period 1930-33, a survey of the coking coals of Western Canada was carried out in a 2 ton capacity oven designed and operated by the Mines Branch. The studies, during this period and subsequent investigations in two ovens of 500 lb. capacity each, demonstrated the application of Canadian coals to the industry in the production of domestic coke, which was supplying an expanding market in the 1930's, and also for the manufacture of metallurgical coke suitable for use in the non-ferrous industry of Western Canada.

Most of the coking coals in Western Canada are in the medium volatile range and, in some cases, there may be dangerous expansion when the coals are carbonized in slot-type ovens. This known fact lead to the development of equipment for the measurement of expansion pressures during the coking cycle, this work being instrumental to a considerable degree in the formation of a sub-committee of ASTH Committee D-5 on Coal and Coke.

In 1939 the Mines Branch co-operated in a study to demonstrate the feasibility of carbonizing coal from the Michel Colliery of the Crow's Nest Pass Coal Company in Curran Knowles ovens. These ovens are a radical departure from the conventional slot-type of oven as they apply sole heating to a bed of coal. The adaption of the process to the Michel coal was advantageous in allowing more economical processing of small tonnages than in the conventional slot-type oven and the mode of carbonization was suitable for an expanding coal. The results of the investigation led to the installation of a battery of 10 ovens and their success may be judged by the expansion to the present installation of 52 ovens.

With the recent interest in the development of an integrated steel industry in Western Canada, requests have been made to evaluate specific seams of Western Canada for use in the manufacture of coke suitable for consumption in a high-shaft blast furnace. Samples from the Crowsnest, Mountain Park, and Comox areas were tested in a 500 lb. capacity movable-wall oven at Montreal. The cokes produced were evaluated for physical and chemical properties by standard methods of testing.

In view of the current market for coking coal in Japan, the Mines Branch, during the past year, has conducted an intensive carbonization program to demonstrate the potentialities of Western Canadian coals for the produetion of metallurgical coke suitable for the Japanese steel industry. The program included the production of test-oven coke from coals and coal blends using Canadian, Japanese and American coals. The evaluation of the samples of coke produeed was made by standard methods in use in North American and Japanese steel practices.

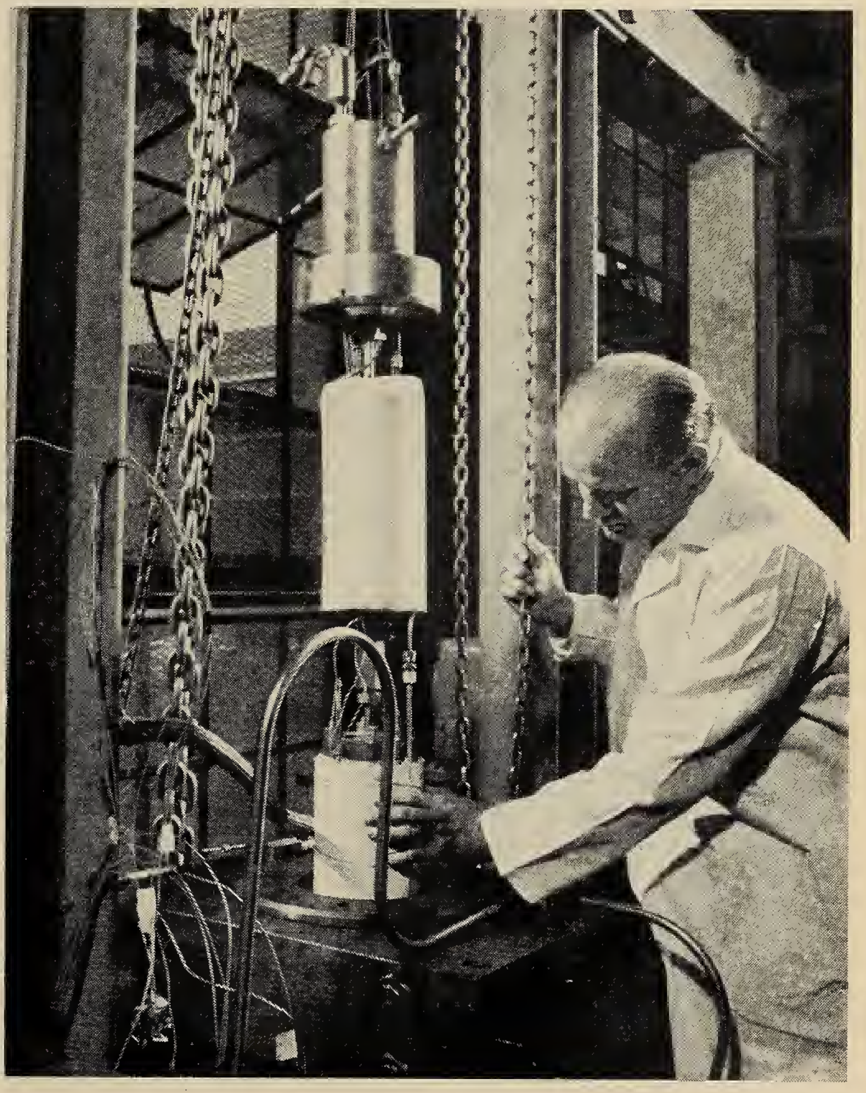
Guaranteed ash contents of Western coking coals for export has stimulated interest in cleaning of fine sizes of coal not amenable to treatment by jigs. A four-tons-per-hour pilot plant for cleaning of slack coals in cyclones using water only has been installed at the Western Regional Laboratory of Mines Branch in Edmonton, in co-operation with the Research Council of Alberta. A two-tons-per-hour pilot plant for cleaning coal in heavy medium cyclones is under construction. Furthermore, research in the dry cleaning of fines is being conducted by studying the interaction of vibratory and centrifugal forces in a pilot machine.

The Mines Branch has recognized the importance of petroleum in the Western Canadian economy for many years, long before the conversion of the railways to diesel oil. Today transportation, which is the life blood of Western Canada, depends entirely on petroleum, and we are indeed fortunate that petroleum discoveries have been able to keep pace with the modern developments in this industry. The relative abundance of petroleum in Western Canada has not always prevailed. During World War II the acute shortage of oil in the Western provinces led to a program of drilling under the direction of Mines Branch to explore the magnitude of the Tar Sands deposits of Alberta. After outlining in one small area a deposit containing a billion barrels of oil the emphasis of the Mines Branch was shifted to problems related to its separation and refining.

The interest of the Mines Branch in the heavy oils of high sulphur content goes far beyond the Tar Sands of Alberta. Experience has shown that the high quality oils are used first and that with the progress of time oils of lower and lower quality must be used. The rate at which this trend affects Canada can be gauged by detailed study of the quality of Canadian oil resources. The Mines Branch performs such a service by analysing oils and natural gases from all the significant Canadian discoveries.

As improved methods of conserva-

Fig. 1. Mines Branch engineer guides the electrically-heated inner reaction chamber into the pressure vessel of the hydrogenation pilot plant.



tion and utilization play a dominant part in the outlook of the Mines Branch, much present research effort is directed to finding new methods to improve the product of Western Canadian heavy crude oils so that these oils may be in a better position to find more stable markets in the face of keen competition.

The conversion of petroleum to refined products using high pressure hydrogen is but one aspect of petroleum refining, and facilities are under construction to provide a balanced pilot plant laboratory for the production of a wide range of commercial products from crude oils which today have limited scope within the famework of the present day refinery technology.

In petroleum technology as in other areas the Mines Branch has an interest in making fundamental contributions to science. In this particular area significant contributions have been made in understanding the structure of petroleum, bitumen, and a wide variety of naturally occurring organic residues that are of interest to the petroleum geologist and those in search of oil.

Mines Branch worked out a cold water process for the economic recovery of bitumen from the bituminous sands of Alberta. The separated bitumen is not, however, a marketable product, and Fuels Division is carrying out a long-term hydrogenation program on the desulphurization of the bitumen and of high sulphur crude oils for the production of marketable products. In this connection, our engineers in 1955 completed the construction of a high-pressure pilot plant which will operate at pressures up to 20,000 p.s.i. They have shown that high-quality diesel oil can be produced at 10,000 p.s.i. Part of the program is directed to the development of suitable catalysts.

Today we are in the era of nuclear fuels and by way of contrast with the mineral dressing problem on tar sands, the present concentration techniques of radioactive ores are chemical in nature.

The Canadian uranium industry began with the Eldorado mine at Port Radium and the Mines Branch developed the process to treat the ore. The original process developed in the early thirties was to recover radium from the uranium-bearing gravity concentrates and later when uranium became important the Mines Branch developed the more efficient acid leaching processes to recover the uranium. The Port Radium leaching plant built in 1952 utilized the processes developed at the Mines Branch. The Mines Branch shared in the development of the high pressure carbonate leach process for the Eldorado Beaverlodge mine, and also developed the atmospheric pressure leach process which was later incorporated into the mill there.

The first private company to develop a uranium mine, Gunnar Mines Ltd., was assisted by the Mines Branch in selecting and modifying suitable processes for its ore. The leaching process selected was a modification of the original processes worked out for the Port Radium mine, and the uranium extraction process chosen was ion exchange, originally developed by the Americans for South Africa. The whole process was tested and piloted in the Mines Branch laboratories.

A number of other Western ores from uranium properties were investigated both on laboratory and pilot scale, but only two, Lorado and Rayrock, reached production. The development of uranium ore processing methods has been a major activity at Mines Branch for well over a decade and has included the processes used in Eastern Canada, in the Blind River and Bancroft areas. Currently extensive research is being applied to means to reduce the cost of uranium.

Today our main extensive work on metallic ores concerns the concentration of low-grade iron ores. Canada has great tonnages of low-grade concentrating iron ores. These have gained much popularity with the steel industry because the use of beneficiated ores has made possible an increase of as much as 50 percent in blast furnace output. Some of the iron ore projects from Western Canada are:

1. Electric smelting of iron ore from Texada Island, B.C.;
2. The direct reduction of sponge iron of oolitic iron ore from Clear Hills, Alberta.

One of our recent and most interesting projects was a joint laboratory investigation by Consolidated Mining and Smelting Company of Canada and the Mines Branch to determine the feasibility of making satisfactory steel from the pig iron which Comico could produce from heretofore waste sulphides. After an elaborate series of experiments on manufacture and testing of steel made from varying amounts of Cominco pig iron, no significant differences could be found from standard steel.

The current development of missiles, ultra high speed air vehicles and atomic energy power plants emphasizes the need for highly specialized alloys, possessing premium properties of high strength-to-weight ratio, high strength at elevated temperatures, and high corrosion resistance. These requirements, as well as many technological problems of the metals industries in Canada and of the Armed Forces, occupy the attention of a large staff of research scientists in the Physical Metallurgy Division.

This short account of the activities and facilities of the Mines Branch should enable you to understand how our engineers and scientists have assisted and are assisting in the development of Canada's wealth of metals, minerals and fuels. I think I should mention that the Mines Branch has a staff of 650, of whom 250 are scientists and engineers. The Branch is located in a large group of buildings in Central Ottawa, in the Booth Street area, and has recently occupied new laboratories devoted to mineral sciences and the development of extraction metallurgy. During the last few years there has been tremendous extension of facilities, to place emphasis on research for the development of new sciences and methods in order to expand Canada's position and importance in the mineral world. This new approach has required the recruiting of numerous research scientists, many with doctor's degrees, and the obtaining of very much new and ultra-modern research equipment. To the question of why all this is being done, I might say that while Canada is endowed with a plethora of mineral resources, comparatively few of these resources can be regarded as in the bonanza class. We are faced with the innumerable problems of dealing with complex and often very low-grade resources which cannot be converted to marketable products without such facilities as exist at Mines Branch to assist Canadian industry in its contribution to the economy.

AIRPHOTO INTERPRETATION IN MUNICIPAL ENGINEERING

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Presented at The Engineering Institute of Canada Western Technical Conference, Banff, Alberta, October, 1959.

This paper is not a review of the techniques of interpreting aerial photographs. Rather, it concerns the applications of airphoto interpretation studies in the initial planning stages of municipal-engineering investigations. The authors describe landscape features often assessed on municipal engineering projects. Information in the paper is based on the last 3½ years work; during this time the authors have carried out 42 airphoto interpretation assignments covering a wide variety of municipal engineering projects. This paper is directed principally toward engineers who are not specialists in airphoto interpretation but who can make good use of information derived from airphotos. It is hoped that information in the paper will help these engineers to know when to recommend air photo studies, know what to ask for, and know how to use the data to advantage when it is received.

ALMOST every major construction project undertaken today considers one or more aspects of the landscape. Commonly it is the type and condition of soil or rock materials in the near-surface zone. In this connection it is often the pattern, depth and variability of different soil deposits, related in turn o their parent geologic landform.[1] On the other hand the aspect of greatest importance may be topography or, in certain areas, surface and subsurface drainage. Less frequently native vegetation is important. Particularly in and around metropolitan centres it is the type and pattern of present land use. Of course it may actually be changes in vegetative cover and changes in land use.

Normally one map is required to show each set of information—be this information on soils, drainage, topography or land use. To the specialist in photo interpretation, however, the airphoto reveals certain data on all of these, and in a single aerial view.[2,4,6] Of course, adjoining photos may be viewed in three dimensions and when this is done a small-scale relief model of natural and man-made features can be seen.

In municipal work it is usually the interrelationship among topography, drainage, different soil deposits, and the distribution of vegetation and land-use patterns that is most significant. Obviously this interrelationship is best appreciated when all these data can be simultaneously integrated and studied at length in a single view, rather than as a series of separate maps placed side by side.

To the analyst who can confidently identify and interpret natural and man-made detail in airphotos, to a large extent the airphoto takes the place of several maps placed side by side or, alternatively, a series of superimposed maps.[7] If the airphoto is properly interpreted it is indeed several maps "rolled up" in one. But the interpreter must be able to correctly identify and evaluate recorded photographic detail.

In selecting new townsites and new resort areas (as well as in assessing peripheral extensions to existing communities) a large proportion of the data needed for decision-making purposes can be extracted from the same set of aerial photos. Sometimes, of course, more than one scale of photography is desirable. And sometimes photographs taken at different times of the year or periodically over several years are especially helpful.

In any event several maps, each map showing a different set of data, can be made from the same aerial photograph (Fig. 1).

Applications of Photo-Interpretation in Municipal Engineering

Selection of New Townsites and New Resort Areas: Following is an assignment the airphoto interpreter is frequently asked to carry out:

In an area select the three best townsites available for new development. Rate these selected area according to first, second, and third choice and give the reasons for your rating. Prepare a set of maps that show a) the general nature of soil conditions and the distribution of significant geologic landforms in each area-of-interest; b) a visual-type classification of topography (e.g., depressional vs nearly level vs hummocky vs gently sloping and so forth); c) drainage characteristics (indicate both surface hydrographic features such as rivers, creeks, draws, lakes and sloughs as well as predicted internal drainage characteritics for different areas); d) the distribution and character (type, density and height) of natural vegetation; e) all cultural or man-made features including transportation and communication facilities, if the latter exist in the area-of-interest.

In addition to the preparation of the above maps, depending on geographical location of the new development, the airphoto interpreter may be asked to make[13]:

1. A regional search to determine whether or not ample supplies of

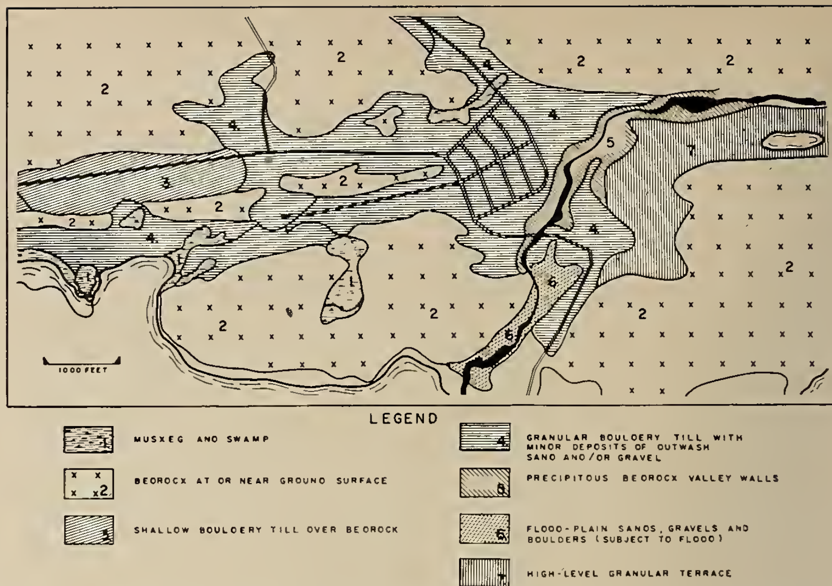


Fig. 2. This reconnaissance map of the Uranium City area shows broad yet important terrain delineations made by studying airphotos. These terrain types influence new housing development and the installation of underground utilities. This map was prepared in connection with planning new development extensions in the vicinity of the townsite.

aggregate materials exist in the area;

2. A study of the possibilities of obtaining surface water or groundwater supplies, suitable in quality and quantity for domestic and industrial use as well as for the disposal of indutrial wastes and sewage;

3. An assessment of the broader phyical environment expressed in mosaics in order to appraise the possibility of hazards to life and property. For instance, consider the possible occurrence of fires and floods, snow avalanches, rock slides and landslides, accelerated erosion and sedimentation problems, permafrost,[3] deep muskeg, volcanic activity or earthquakes caused by recurrent movement along "active" faults. The possibility of any of these or other hazards actually occurring is of course subject to geographic limitations. But certainly the hazards pertinent to any region should not be overlooked in any preliminary examination;

4. An appraisal of prospective earthwork and foundation problems at potential building-site areas—for example, depth to substrata capable of sustaining heavy buildings, the assessment of excavation problems (groundwater, bedrock, highly compressible soils) associated with the installation of underground utilities and deep basements for tall buildings;

5. A general layout of transportation systems, including accessibility to the new site by water, air, rail and highway;

6. An appraisal of natural landscape features, particularly as they affect storm-sewer design, location of playgrounds and parks and the pattern of street layout;

7. An estimate of the fertility of soils in the vicinity as this might affect lawns, gardens, vegetable and other crops grown for local consumption.

In each of these studies the photo analyst usually works for or with a specialist who is responsible for carrying out detailed work on the ground. Especially in little-known, unmapped areas the photo-analyst specialist can do much to simplify and expedite the ground observer's task by compiling pertinent information and by systematically preparing sketch maps showing relevant physical and cultural features (see Figs. 2, 3).

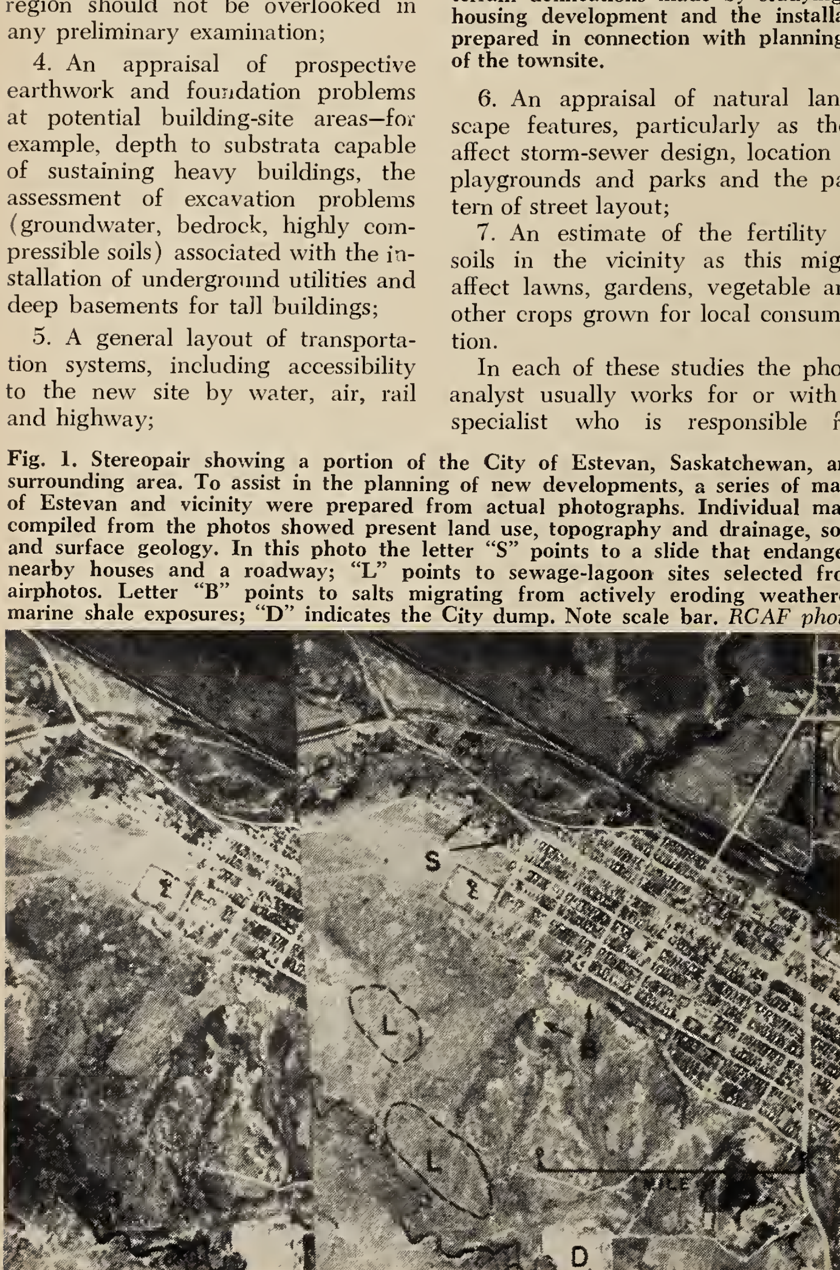
Specification-Material Searches: No single airphoto study is requested more often than the search for undeveloped sources of sand and gravel.[10]

Searches may be made for materials that must meet high-quality standards, such as coarse-aggregate deposits for making concrete (Fig. 4). Or the searches may be made for materials to be used as subbase on paved streets, in which case the governing specifications are considerably less rigid.[11] In most search areas studied on the prairies, deposits suitable for subbase far outnumber those deposits that are suitable for concrete aggregate. A knowledge of the location of all prospects is needed to determine the most economic deposit to develop.

Airphoto studies have been carried out in search of clay deposits for lining sewage-lagoons and town reservoirs and for clay materials for capping streets and roads wherever cohesionless sand is the subgrade material. Filler sand for use in bituminous paving mixtures has been sought and discovered from airphoto study. Organic deposits for application to lawns and gardens may also be located.

Groundwater Appraisals for Cities

Fig. 1. Stereopair showing a portion of the City of Estevan, Saskatchewan, and surrounding area. To assist in the planning of new developments, a series of maps of Estevan and vicinity were prepared from actual photographs. Individual maps compiled from the photos showed present land use, topography and drainage, soils and surface geology. In this photo the letter "S" points to a slide that endangers nearby houses and a roadway; "L" points to sewage-lagoon sites selected from airphotos. Letter "B" points to salts migrating from actively eroding weathered marine shale exposures; "D" indicates the City dump. Note scale bar. ***RCAF photo.***



and New Industries: In addition to selecting potentially favorable groundwater environments to drill and test (Fig. 5), the airphotos are commonly studied in an effort to a) detect springs (Fig. 6), b) appraise the salinity and mineralization potential of the groundwater in the locality under study, c) determine the possibility of recharging near-surface aquifiers (Fig. 7), d) identify water-bearing fissures in sandstones, limestones and Shield areas, even where these rocks in some instances are masked below surficial deposits.[13]

In mountain and foothill areas containing alluvial fans and valley-fill deposits it is often possible to locate areas where water-bearing strata are confined between impervious soil or bedrock materials.

Buried preglacial valleys in glaciated country occasionally show up on aerial mosaics owing to a regional slight darkening in airphoto tones.

High costs of groundwater exploration associated with random drilling methods point out the need for some reasonably cheap means for isolating the most promising places in which to concentrate subsurface explorations, including earth-resistivity surveys. Airphotos, properly used, are such a medium. But airphoto studies should always be followed by field examination. The photos should be analyzed in the light of all pertinent available subsurface data.

Airphoto interpretation for groundwater prospecting must be done with a good appreciation of factors that control the availability of groundwater. In this connection three factors

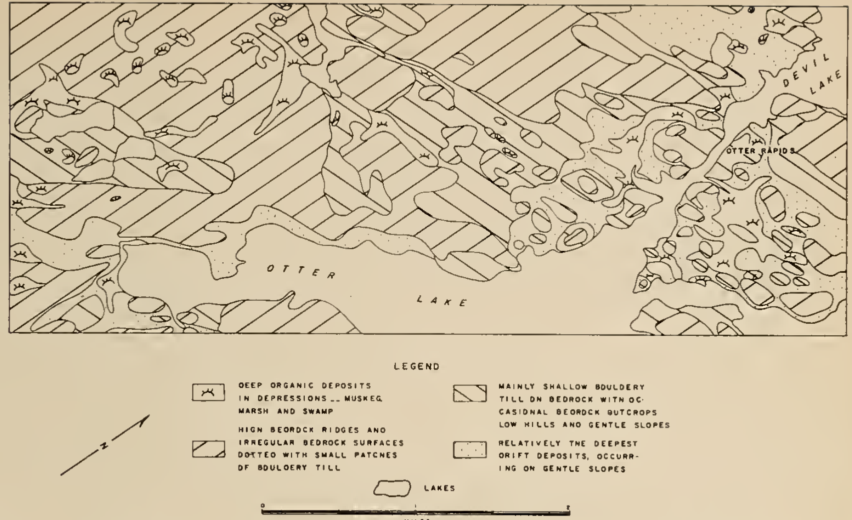


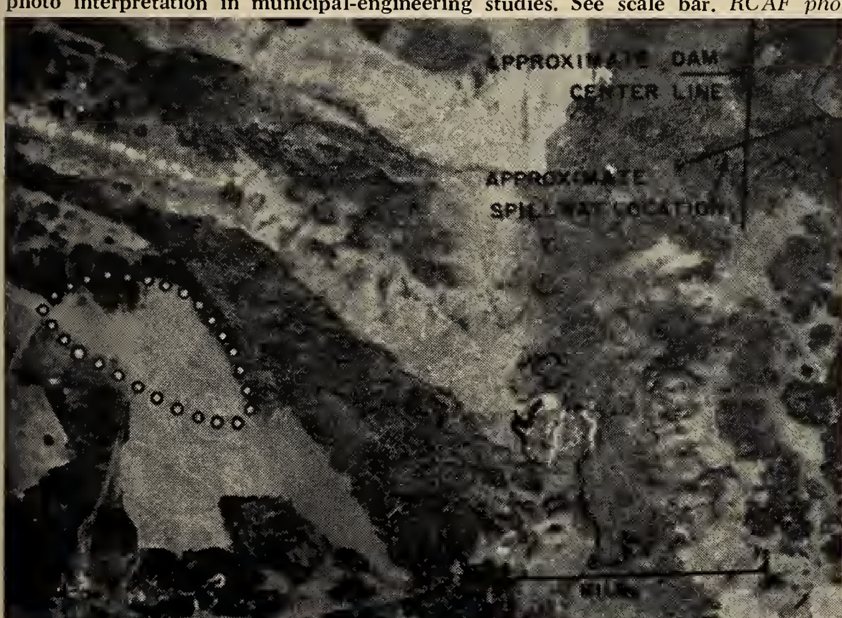
Fig. 3. This figure shows a generalized terrain classification map prepared from four inch equals one mile scale aerial photographs. A forty acre tract of land was desired for a new townsite in this rugged Precambrian Shield country. The terrain found here consists of lakes and muskeg interspersed with high rock hills. Actually very small areas of land are available for new townsite development; and what land is available is irregular shaped, small in extent, and consequently of little value. The better prospective townsites were selected and rated as first, second and third choice. Reasons for this rating were detailed in the report. No areas can be considered as even "fair" townsites. This sort of map is usually prepared before field investigations commence. See scale bar for size of area mapped.

are of prime importance. They are a) the character of the near-surface deposit—whether, for instance, it is bedrock, sand and gravel, or a clayey type of material; b) the availability of water which infiltrates into the groundwater reservoir—a function of climate, drainage-basin size, shape and characteristics; and c) possible underground movement of water—a function of local relief and variations in the character of the subsurface materials.[13]

Indicator clues to possible groundwater sources decipherable in aerial photos vary from region to region. The clue observed in photos may be a deep sand or gravel bed that extends back from a river or other large body of water; an old valley that has been deeply infilled with glacial drift or alluvium; deep sand dunes resting on bowl-shaped impervious strata at depth; or well-defined seepages on valley slopes and hillsides. The observer must recognize these features in photos. And he must be able to interpret their significance in laying out a drilling and aquifer-testing program.

Fig. 4. This photo illustrates a coarse gravel deposit discovered originally from aerial photographs. This subtle-appearing deposit was used in the construction of a concrete spillway (see upper right). Reservoir water impounded by the dam is used as a town water supply and for recreational purposes.

Location of constuction aggregates is one of the principal applications of photo interpretation in municipal-engineering studies. See scale bar. ***RCAF photo.***



Assessing Surface Water Supply Possibilities: The interpreter undertaking a study of surface water sources is usually given a radius around a town or city that he must "size up" and report on (Fig. 5). The observer should have an idea of the economic distance he can go for a municipal water supply and an estimate of the quantity of water required to meet future demands. Normally this information is supplied to the photo interpreter.

In such a study aerial mosaics covering large areas are first inspected with a view to selecting reservoir sites capable of storing sufficient water to satisfy present and future demands.

Where stream-flow records for small creeks are few or not available, it may be necessary to measure the size of drainage basin and make an estimate of the actual area contributing to stream flow. On the prairies it is well known that in many areas most of the spring and rainwater runoff discharges in sloughs, so that only a

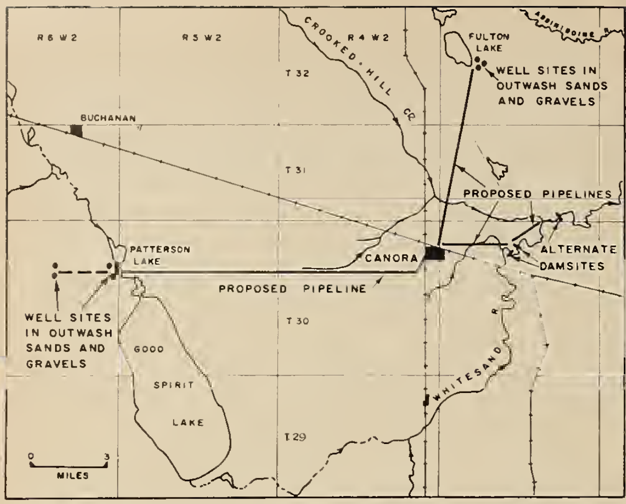


Fig. 5. This key map shows the results of an area-wide airphoto study in search of potential ground-water and surface-water schemes in the vicinity of Canora, Saskatchewan. Once all promising-looking sites for ground-water development and surface water storage were identified, the conditions at each site were in turn studied in detail in the airphotos.

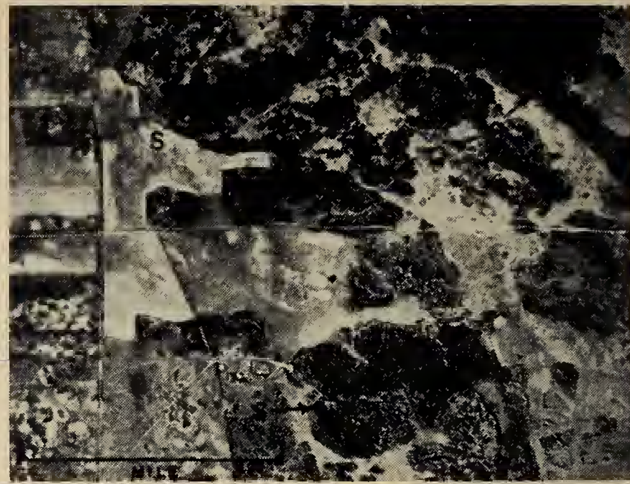


Fig. 6. This portion of an airphoto shows a series of large springs east of Rosthern, Saskatchewan. They were identified in connection with a regional search for a suitable town water supply. Note their characteristic shape. Blowouts in the lower left corner of this photo (small dark-toned areas) indicate that the surficial materials here are sands. See scale bar. ***RCAF photo.***

small percentage of the runoff actually reaches creeks and rivers. When considering the character of the drainage basin, usually all that is required is a general statement on topography as it effects runoff; subsoil permeability; vegetative cover; and cultivated versus uncultivated land.

In a few instances runoff from one drainage system can be diverted into a second drainage network and so increase the amount of water available. Close liaison with a hydrologist is desirable.

After assessing possible yields to prospective town reservoirs and ways of augmenting this yield, the damsite and reservoir areas are considered.[9] If the dam being considered is a large and important structure, then the following features should be reported on in an airphoto appreciation[13]:

a) Deductions and inferences concerning the geologic origin of the valley at the potential site—in particular, its erosional and infilling history. This prefield study serves as an excellent basis for future closeup studies on the ground;

b) Composition and probabe character of materials in the dam abutments and in the valley bottom with special emphasis on mode of deposition of the unconsolidated materials as well as on any apparent structural defects or detectable seepage channels in the underlying bedrock—should the character of bedrock be significant because of its proximity to ground surface;

c) Delineation of all bedrock outcrops, areas of shallow cover, and a qualitative estimate of depth to sound bedrock or other competent material, where surface features, geologic setting and observable outcrops permit a reasonable estimation. The disposition of rock outcrops along valley sides often suggests a tentative dam centerline as well as the possible layout of appurtenant structures;

d) Location of probable routes of excess seepage in the immediate vicinity of the dam and around the reservoir rim;

e) Detection of old and recent earth movements and other structural weaknesses (faults and joints) in the vicinity of the damsite and appurtenant works and around the reservoir rim,[15]

f) Determination of the availability and prospective suitability of various types of construction materials in the vicinity, pinpointing locations to check in the field;

g) Suggestions as to the type of dam to construct in view of the above considerations;

h) Suggested preliminary layout of appurtenant structures, taking into account natural topographic features and prospective foundation conditions, where these are to some extent assessable. Structures ordinarily included in this appraisal are diversion works, spillway, powerhouse, penstocks and canal structures where required. For each structure, alternative layouts may be suggested to take advantage of certain natural conditions—e.g., tunnels versus cut-and-cover conduits;

i) Determination of approximate storage capacity and flooded area where existing topographic maps and form-line construction from aerial photos make this a feasible proposition;

j) Search for evidence indicating the probability of accelerated sedimentation in the reservoir; also, evidence suggesting possible retrogression of the river-bed downstream from the dam;

k) Appraisal of flood damage to existing transportation and communication systems, to valley farm and pasture lands, stands of merchantable timber, farmsteads, population centers.

Selection of Sewage-Lagoon Sites: To make a worthwhile airphoto assessment of potential sewage-lagoon sites around a town or city the interpreter should have some idea of regional slopes so that sewage wastes flow by gravity from town to lagoon sites (Fig. 1).

Requests for the location of suitable lagoon sites frequently call for alternate locations and a statement of the pros and cons of each site that is chosen.

In selecting a lagoon site from aerial photos, other things being equal, the photo interpreter derives information on the following:

a) Size of tracts of non-commercial land that are available for development and the possibilities for future extensions to selected lagoon sites;

b) Type of excavation (e.g., large boulders vs till);

c) Subsoil permeability (e.g., heavy clay vs clean sands and gravels);

d) Type of borrow material available for dike construction;

e) Proximity to farmsteads or other dwellings;

f) Relative amounts of organic topsoil that must be removed from the site;

g) Comparative volumes of grading required to level different sites;

h) Comparative elevations of the

townsite and the proposed sewage-lagoon site;

i) Existence of natural channels leading away from proposed lagoon sites;

j) Prevailing wind direction;

k) Present use and value of land that must be acquired;

l) Pipeline length from town to the lagoon and terrain conditions along the selected route.[12]

In selecting alternate sites and assessing their relative merits the photo interpreter will often list the above points, item by item, and then comment on each. As with all airphoto-based studies, places to field check and features to field check are noted directly on plans accompanying the report.

For most towns, an airphoto study for possible lagoon sites can be completed in one day.

Less Common Applications: In the 42 individual airphoto studies carried out in connection with municipal-engineering investigations and used as a basis for this paper, as mentioned previously some studies were requested much more frequently than others. The more common applications are covered above. Contained in the list below are less common studies in which we have been requested to:

a) Select a cemetery site;

b) Map and classify slump and landslide features adjoining built-up city property as well as near proposed new townsites (Fig. 9);

c) Assess the relative stability of proposed alternate town reservoir sites where situated on former landslide or slump topography;

d) Select dugout locations for use as a town reservoir;

e) Locate clay materials for lining a sewage lagoon situated in an area underlain by sands (Fig. 8);

f) Locate the best site for a river intake, considering foundation problems and the possibility of erosion or sedimentation taking place at the intake;

g) Assess the likely quality of surface water supplies (lakes, for example) from an inspection of indicators suggesting contamination by chemical wastes, high concentrations of "alkali" salts[8] or undesirable algae growth around lake shores;

h) Locate a sewage outfall main to avoid as much as possible the following: muskeg, permafrost, large boulders, and bedrock;

i) Detect the most likely course of a deeply drift-filled valley in shale bedrock, using as a clue the presence or absence of major slumps that have in the past been induced by movement in the weathered surface of shale bedrock—where, also, the shale surface lies above the base of the valley floor;

j) Locate a pipeline route between a group of wells yielding groundwater and a townsite;[12]

k) Map drainage conditions as they affect new housing and industrial development.

When to Make Airphoto Studies

To be most useful, the airphoto study should be made before any appreciable amount of field work is undertaken. Very often, unfavorable terrain situations can be avoided and field work concentrated in places where it will do the most good. In addition the field engineer, who may or may not be the photo interpreter, visits selected points with a view to obtaining specific and detailed information. Of course his first job is to confirm or disprove data and inferences resulting from his photo study.

By carrying out photo studies at an early stage during an investigation the engineer not only economizes on field work—today becoming more and more costly—he also makes sure that favorable situations are not overlooked just because they are not apparent from the limited perspective so often accorded a person on the ground. The method also provides a way of developing preliminary information for design purposes at a relatively low cost.

Determining What Data Are Required

Municipal engineers and consulting engineers doing municipal work are best qualified to assess the sort of information they would like to get from an airphoto study. This task is naturally much simplified if the engineer requiring scattered terrain data has a general appreciation of what can and cannot be interpreted from the pictures. To solve this, one method that has worked well is for the photo analyst and the engineer requiring data to get together and list, point by point, all information desired and also information that exists and may be procurable. Until the photos are examined, even a competent specialist with considerable experience does not know precisely what and how much data can be obtained.

Fig. 7. A map prepared from a study of airphotos. In the search for water supplies the airphoto interpreter must always be alerted to the possibility of recharging potential near-surface acquifers. First of all the interpreter must determine whether or not a potential acquifer exists; subsequently, determine its characteristics. Then he must ascertain whether or not an assured source of recharge water is available nearby. A good example of this development on the prairies is the present Camrose water-supply system in Alberta.

In the area shown here the granular material in locality "A" is both coarser textured and deeper than in area "B".

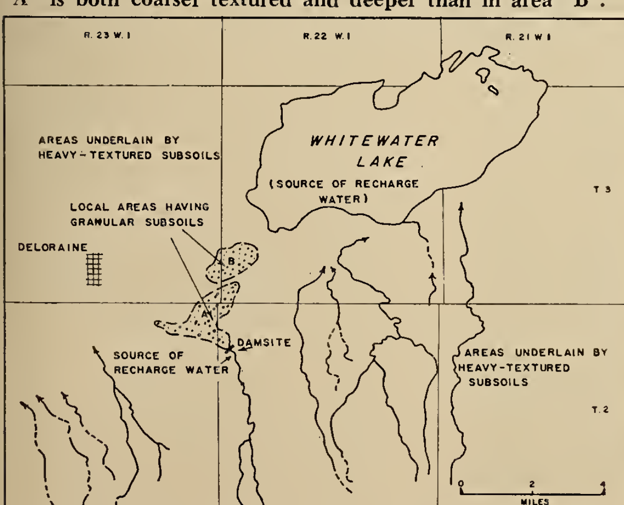


Fig. 8. Photo showing landscape features north of Saskatchewan Hospital, A, located near North Battleford. Purpose of the airphoto study was to locate impervious lining materials for a nearby sewage lagoon situated in sandy soils. Surface deposits here are shallow sands, which, in turn, overlie glacial till. Area "B" was selected as first choice for a clay borrow pit. Letter "C" shows a low cigar-shaped ridge, indicating here the local direction of glacier ice movement. See scale bar. *RCAF photo.*

The Use of Reference Material

For reference purposes the interpreter of aerial photographs should have an up-to-date library of published maps showing the surface geology, agricultural soils, drainage, contours, and the rest. Usually each map adds something to the overall picture and makes the final product just that much more complete and meaningful. But many times the objectives of these maps, their early date of publication, or their small scale may mean that they can be used as a guide only. Even so they often lend assurance to the digested airphoto detail or, on the contrary, arouse suspicion of possible errors in photo interpretation. No procurable map that shows landscape information should be overlooked.

How Data Are Shown

Where the magnitude of a job warrants the added expenditure for mosaic preparation, the photo-derived data should be shown either on the mosaics directly or on mosaic overlays. That is to say, data are best shown on transparent tracings to the same scale as the mosaics they overlay. Otherwise, the information may be shown on small-scale township plots or small-scale regional maps.

The more information that can be shown directly on plans, the more useful the results. Pertinent notes are also best recorded right on the plans. If the interpreter is unsure of his interpretation, where this uncertainty applies it must be clearly expressed. Field check points should always be indicated on the prints. And the sort of information the aerial observer expects to find on the ground should be appropriately noted.

How Data Are Used

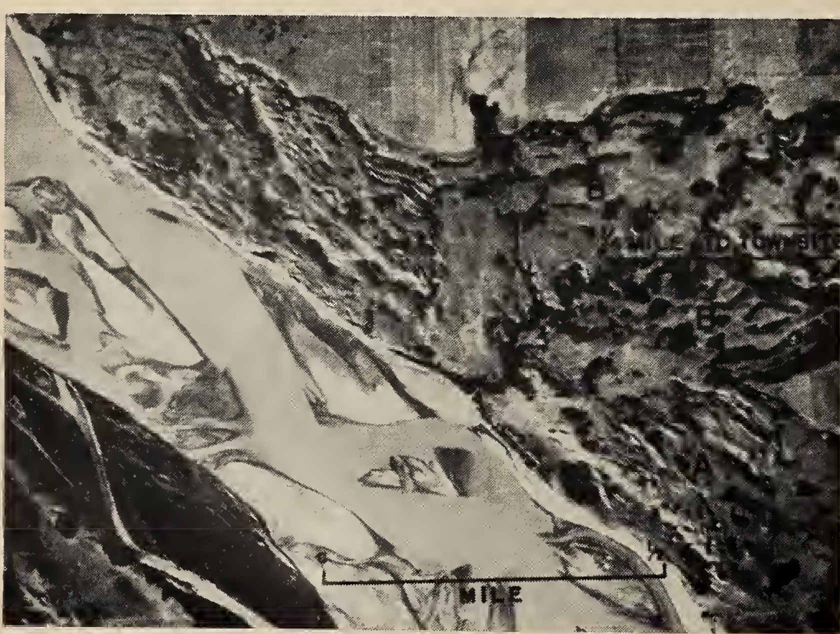
Aerial prints or tracings showing interpreted airphoto information are commonly taken to the field. Depending on the development stage of the project under consideration, the data shown may be used in preliminary design work, for preliminary cost calculations, assessment of relative costs of different alternatives, appraisals of problems and an estimate of their probable magnitude, and in some instances recommendation for possible solutions.

Preliminary estimates may be used in determining rough earthwork quantities for a dam, the approximate amount of storage capacity in a reservoir, the length of pipeline between a reservoir city and the town it serves, comparative costs of trucking aggregates from different sources.

Conclusions

The relative success of an airphoto undertaking depends not only upon the quality of tools at the disposal of the interpreter (good reference maps and scale and quality of airphotos, for instance) and the personal capabilities and experience of the analyst, but also the whims of nature.

Fig. 9. A new town has been recently built on level ground just a short distance to the east of the area seen in this airphoto (see arrow). Water supply and sewage disposal systems for the new community rest in part on valley-side topography, which as seen here shows a great many slump features. Areas marked "A" show features associated with relatively recent dislocation of slope-forming materials. Areas marked "B" appear more stable and do not reveal the preponderance of "active-looking" slope-instability features. The critical nature of all these slopes is of course well known and their condition is carefully considered wherever new construction on them is contemplated. *RCAF photo.*



Airphoto data should be derived as quickly as possible and should be presented in usable form just as concisely as possible.

Facts, inferences, and speculations should be separated and these different degrees of certainty should be plainly labelled on maps and in reports. Statements should be qualified where inferences replace facts and where speculation replaces inferences. These three degrees of certainty should not be confused.

Success in this work demands a working knowledge in the field of application; background training in soil mechanics, engineering geology and geomorphology; and widespread experience in airphoto interpretation. Careful observation and the interpretation of significant facts, however subtle, play an essential part of this work. Although field work may be drastically reduced, airphoto interpretation by itself is seldom a substitute for field study. Usually both are necessary to carry out any regional program involving appraisal of landscape factors.

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THE DUNVEGAN SUSPENSION BRIDGE

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In June of 1956 the Alberta Department of Highways decided that the ferry across the Peace River at Dunvegan, Alberta should be replaced by a permanent two-lane highway bridge. The crossing is located about midway on the river between the bridges at Taylor Flats, B.C. and Peace River, Alberta and on the main highway connecting Grande Prairie and Peace River.

THE CHOICE of site was not limited to the immediate vicinity of the existing ferry crossing but several factors ruled in favor of this location. A great deal of money had already been spent by the Department of Highways stabilizing the north hill approaches and there appeared to be no better potential outlet to the south than Dunvegan Creek. The Peace River valley is about 800 ft. deep in this area so that exit on a reasonable grade could only be attained by use of an existing drainage channel. An evaluation of all these factors led to selecting a site about 500 ft. upstream from the existing ferry crossing on a skew of about 30°. Preliminary foundation investigations showed that the river had been scoured into over-consolidated clay previously loaded by glaciers. The main river channel near the south shore is about 15 ft. deep at low water and the bed is about 15 ft. above the hard clay. The north side of the river bed consists of 70 ft. of sand and gravel overlaying the over-consolidated clay. The thickness of the gravel bed decreases uniformly towards the south shore. The river bank on the south side rises quite steeply in the same material as the river bed for some distance with beds of highly compressed sand and finally gravel deposits about 100 ft. above river level. The north river bank consists of about 30 ft. of river deposited silt on top of the same layer of river deposited sand and gravel found in the river bed. Fig. 1. shows the foundation profile at the crossing.

Scour

Scour studies based on flood records, bed material and percentage of stream area affected indicated the river might scour around the large piers as much as 80 ft. below maximum flood level (determined as about elevation 1145). Normal flow in the Peace River is approximately 30,000 c.f.s. with a maximum recorded flood in excess of 400,000 c.f.s. in May, 1948.

In view of this fact it was undesirable to locate the pier bases on river deposits and the decision was made to locate the river pier bases at elevation 1065 or at the level of the hard clay, whichever was the deeper. Stream bed is about 1100 in the main channel, low water is around 1113 which is slightly below stream bed near the north shore and the north bank is slightly above maximum expected flood level.

Foundations

Field and laboratory investigations showed that the bearing capacity of the over-consolidated clay would be determined by elastic deformation rather than ultimate strength. A compromise figure of 10 tons per square foot was selected for the design of foundations on the over-consolidated clay with smaller values on the normally consolidated clays.

Recommendations

Preliminary cost estimates showed that expensive river piers would dictate relatively long spans. Various types and spans were investigated with the final choice falling between either a suspension bridge with two river piers or a cantilever truss bridge with four river piers.

The suspension bridge was recommended rather than the cantilever because it contained less structural steel (which was in short supply at the time of the preliminary investigation) and because half as much river work would be involved. Generally the unknowns and hazards of river work are greater than work on dry land or above water and therefore the cost of deep piers is less subject to close analysis than the cost of superstructure or land anchors. The contractors appeared to agree with the latter conclusions since no bids were received until the deep river pier foundations were put on a force account basis.

Project Layout

The minimum length of bridge which would clear the river on the 30° skew with land based foundations a safe distance from the river, was 1800 ft. The suspension bridge was therefore laid out with 900 ft. center span and 450 ft. side spans. The north anchorage was to be carried to gravel so was located only 100 ft. back from the river bank and could carry the north cable saddle and rocker. The south anchorage had to be located in over-consolidated clay so was kept back 250 ft. from the river's edge. The south cable saddle and rocker were carried on a separate steel bent near the edge of the river. The north end of the crossing was kept at a reasonably low elevation since the silt could not be expected to carry a very high fill. However a grade of approximately plus 3% to the south, together with 575 ft. of approach span including 150 ft. of spiral and 194 ft. of 4° curve, not only improved alignment at the south end but made the new approach road cross the old ferry road near the end of the bridge. This is considered important since any approach road along the banks of Dunvegan Creek is bound to require time for stabilization. In the meantime the existing exit, which is steep and not subject to slides since it follows contours, will be available for emergency use.

Model Study

In view of the size of the project it was decided that a model study of the principal structure would be justified. The preliminary design, and hence the model, used a cable sag of 110 ft. which was later changed to 100 ft. for the final design. Space does not permit a full discussion of the design and testing of the model but certain features are of interest. Briefly a linear reduction factor of 180 was used together with a slicing factor of 4. The towers and stiffening trusses were simulated by solid steel members carefully machined to account for proposed changes in stiffness. The bases of the towers were notched to simulate pins and piano wire was used for main and hanger cables. The piano wire was clamped at the tower tops and at the end of the span while the hangers were run through the stiffening truss and clamped below. Dead weight cans, partially filled with lead to match dead load, were attached at the panels point and lead shot was added to represent live load. The whole model was then mounted on a laminated wooden base to keep temperature movements of the base to a minimum. The base had provision for the proposed change of grade from one end of the bridge to the other. Ames dials capable of reading movements directly to the nearest 1/1000th inch were located at mid-span of the side spans and at the mid and quarter points of the center span. Duplicate sets of readings were then taken with all design combinations of live load. Observations were also taken at nine different locations to one side of center under the condition of a single moving concentration. Observations were also taken of the movements which occurred during a 50°F change in temperature. In addition the wind load on the towers and trusses was simulated by lateral spring loads and the corresponding lateral deflections observed. The deflection readings were all converted to prototype and from these bending moments and shears checked.

Agreement between deflections obtained from the model and theoretically computed ones was well within the limits of experimental error. Fig. 2 shows a photo of the model while Fig. 3 shows several deflection curves obtained by converting readings on the model to prototype. Lack of symmetry due to the fact that the bridge is on a grade caused the low point on the cables to shift about a panel off of center line. The influence lines for points symmetrically located as to distance will not be exactly the same.

Readings taken for the points located symmetrically with respect to the towers show that the maximum deflection reading can vary as much as 10% apparently due to lack of symmetry of the cables. This lack of symmetry makes the conversion of model deflection to prototype moments and shears difficult. However calculations to a sufficient accuracy for preliminary investigations were very useful.

Final Design

The knowledge obtained from the model study showed that the general dimensions chosen for the bridge were of a satisfactory order as were all likely deformations due to load, temperature and wind. The detailed designs of the bridge and its foundations could therefore proceed.

Substructure

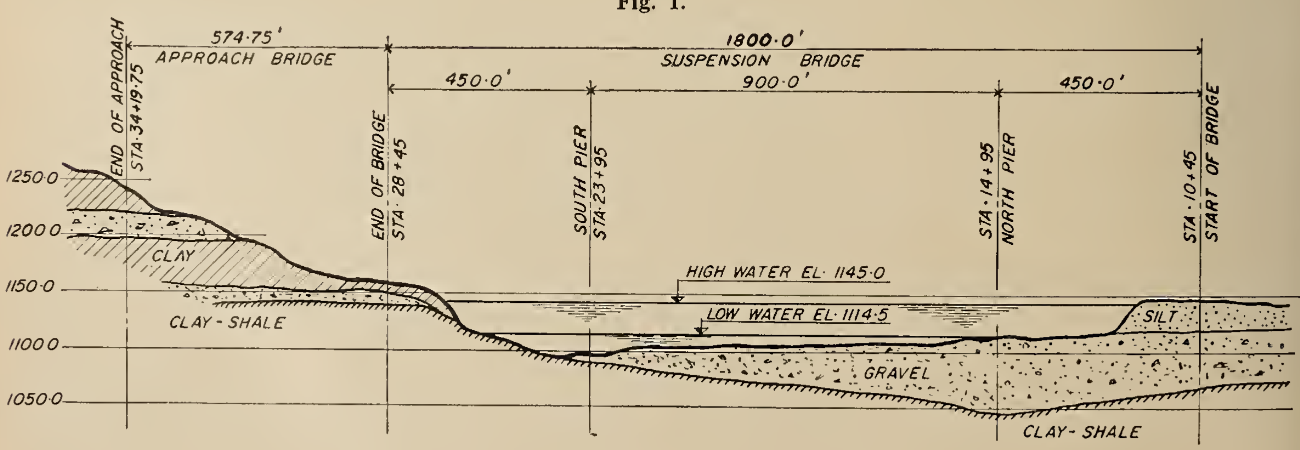
The design of the foundations resolved itself into two principal problems, viz. the underwater pier bases and the pier tops and land based foundations.

The north anchorage was carried down through the silt into the sand and gravel to elevation 1106 at the back side and stepped to 1112 at the front. The sand and gravel base was consolidated by driving steel H-piling and during high water it was necessary to install well points to maintain this consolidation until after the dead load of the concrete was in place. The total dead weight of the north anchorage is 18,400 tons with a net effective submerged weight of approximately 14,000 tons. The maximum horizontal component of cable tension is approximately 3500 tons due to the combined effect of live and dead load which means a coefficient of friction of approximately 0.25 was used. The anchorage is made up of cellular construction with gravel ballast as economical dead weight. The south anchorage being completely above high water has a gross weight of concrete and ballast of 14,000 tons and is of similar concrete cell construction to the north anchorage. The cables entering the south anchorage have a vertical component which is offset by the dead load reaction of the towers carried on the anchorage.

The design and construction of the two river piers cannot be covered in detail. Briefly it can be said that standard cofferdam procedure was abandoned for the north pier early in the preliminary investigations on the realization that sheet piling could not be driven through the sand and gravel to the shale. In any case the bracing for such a cofferdam would be extremely expensive.

The decision was reached to design a caisson which would be sunk

Fig. 1.



FOUNDATION PROFILE

SCALES: HORIZ· = 1" = 250'-0
VERT· = 1" = 100'-0

through the sand and gravel by dredging until it reached the over-consolidated clay below. The design conditions were an assumed ice force of 1500 kips acting at elevation 1115 together with the effects of dead load, live load and wind. These requirements called for a pier base of almost 2,600 sq. ft. from the point of view of stability and permissible bearing. The final design was a three cell hollow caisson 86 ft. by 30 ft. with 5 ft. reinforced concrete walls analyzed by moment distribution for lateral pressures and checked by the coefficients published by the Portland Cement Association for a 3 cell box culvert. The cutting edge was reinforced by steel plate and the walls were notched to key a concrete seal 20 ft. thick in the bottom after the caisson was in place. It was proposed to fill only the upstream cell with ballast in order to offset the fact that the pier shaft had to be located off center to permit the construction of the starling. The top was also notched to provide support for the framework on which to pour a 5 ft. thick slab. This slab was intended to be left at elevation 1105 above which the pier shaft and cap would be constructed. The caisson was designed on the assumption of an average side friction of approximately 750 p.s.f. It was assumed that it would be necessary to "glory hole" or remove the sand and gravel for about 15 ft. deep around the caisson and load with about 700 tons of ballast to sink the caisson to the required elevation 1048. In addition holes were cast in the walls of the caisson clear to the cutting edge and lubricating holes were connected to the side so that water or mechanical means might be used to help loosen rocks or gravel.

Side friction is very difficult to estimate since it is a function not only of the density but the composition of the material. The preliminary investigations could not possibly evaluate these accurately throughout the depth so assumptions had to be made. Lee[1] shows in his Table XI, Page 129 the highest average value of skin friction for a mixture of sand and boulders and a depth of 100 ft. below low water as 660 lbs. p.s.f.

The caisson was constructed on a gravel island and launched by building the first 11 ft. high section on a concrete pad temporarily reinforced by removable bolts. When the concrete had cured sufficiently the launching was accomplished by removing the reinforcing and dynamiting the thin concrete slab. Excavation inside the cells was accomplished at first by clam shell and later supplemented by an air-lift pump consisting of 10 in. pipe, fed at the bottom by a 2 in. air line hooked to two 600 c.f.m. compressors.

Fig. 2. Photo of Model

Very little trouble was encountered until the caisson reached about elevation 1065. Although side friction had naturally increased it became evident that a region of higher than normal friction had been encountered. At this time bison head was brought up during excavation which indicated that the river had run for some appreciable length of time near this level. This is significant from two points of view. Firstly, the increase in friction meant that a well graded mixture of boulders, sand and gravel resulted in a layer of maximum density. Secondly, the fact that no other dense layers had been encountered on the way down meant that most of the upper 50 ft. was in a relatively loose state. If this is the case it is possible that the river could scour in a single major flood to elevation 1065. The original design had assumed that approximately 15 ft. of "glory holing" plus a surcharge of 700 tons would be required to sink the caisson. In actual fact more than 30 ft. of "glory holing" plus 1800 tons of ballast were required to sink the caisson. This works out to an average skin friction value of 1300 p.s.f. or almost double the design value. The caisson was maintained within an inch or two of its final lateral position throughout its descent so no problems arose there. Shale was encountered in one corner of the excavation 3 ft. higher than indicated in the test hole log so the caisson was halted at this level. The bottoms of all cells were cleaned out down to shale and the seal concrete poured in contact with the shale over the full area. It is believed that this is one of the largest open caissons sunk in Western Canada and perhaps the largest ever on the prairies.

The south pier was designed as a conventional spread footing to be carried about 15 ft. into hard shale to elevation 1065. The design was therefore not unusual but the construction was very unusual and worth brief mention. Due to the very hard shale it was recognized that although the material would scour in time it nevertheless would not permit sheet piling to be driven to the bottom of the excavation. The final cofferdam design called for a very heavy sheet piling to be driven as far as possible into the shale (about elevation 1080) in a rectangle stepped back about 6 ft. from the neat lines of the footing. Bracing frames were designed to drop into the cofferdam and be wedged in place as excavation proceeded and it was then proposed to excavate to the neat lines of the footing for 15 ft. below the bottom of the sheet piling. The bottom frame was jacked tightly against the shale to prevent leakage, which proved useful before completion of the base pour. Excavation in the shale was carried out by air hammers and clam shell. An innovation which worked well was the use of a small caterpillar front end loader. This machine moved all loose material to one corner of the excavation so the clam shell always lifted a full load. Confining the operations of the clam to one spot was also a safety measure since it was less likely to damage the bracing.

The south anchorage is similar in design to the north anchorage except that it is smaller since it is above high water. Since the base of the south anchorage is resting on the over-consolidated clay it was decided to take precautions against seepage pressures building up. The plans therefore called for the front of the anchorage to be poured to the neat lines of the excavation for the bottom ten feet while the back has a two foot thick gravel backfill connected to a drain at elevation 1145. The drain is piped to the river bank in a 6 in. sub-drain pipe. The upper 6 ft. of the backfill behind the anchorage is mechanically compacted clay so that

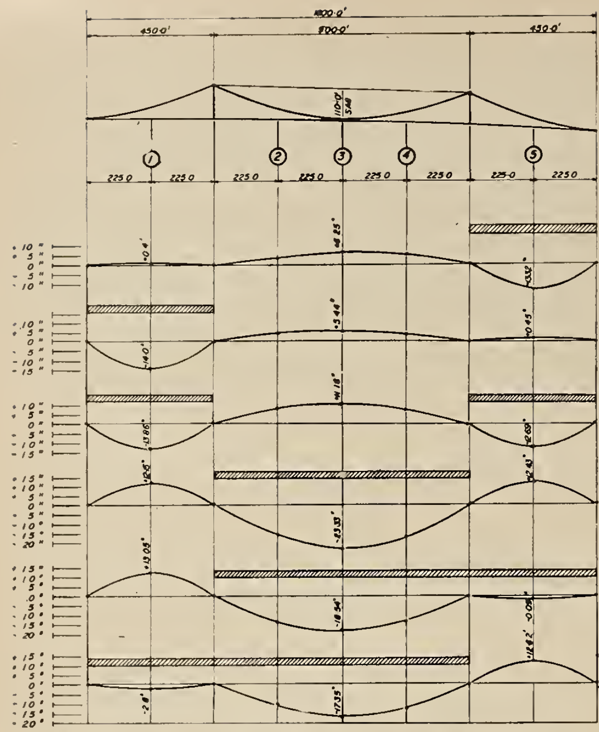


Fig. 3. Live Load Deflection—Curves for Prototype

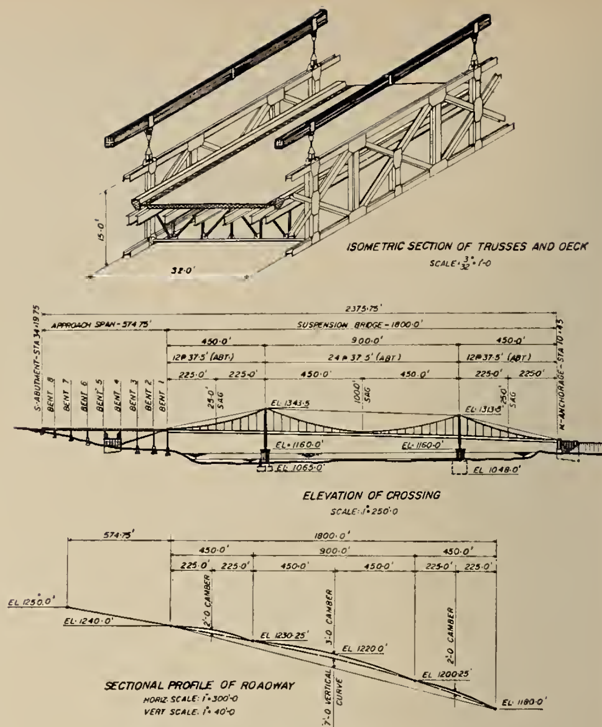


Fig. 4. General Layout and Section

most of the surface water will not be carried into the sub-drain near the anchorage.

The construction of the foundations for the Dunvegan Bridge was unusual and difficult. However the caisson was launched and sunk successfully in accordance with the original scheme. The south pier base was a very difficult problem since it required an open cofferdam 42 ft. by 97 ft. 60 ft. deep. This pier was completed in accordance with the original design and the excavation was carried out in the dry. In both cases the problems encountered were within the range of what might be expected any time work is carried out at great depths in large rivers. As mentioned previously the river work below elevation 1105 was constructed on a force account basis. The cost of this force account portion of the work was within range of the engineering estimates. The total cost of the two river piers was less than $1 million which is slightly less than the engineering estimates at the time of the preliminary investigation.

Superstructure

The tops of the piers were located at elevation 1160 approximately 15 ft. above maximum high water. The only exposed structural steel below 1160 is the cable anchorage at the north anchor. This is not considered serious since this steel is above high water and not in the path of floating debris. Fig. 4 shows the general layout of the project with important dimensions, elevations and a typical cross-section near the center of the suspension bridge.

All structural design is in accordance with the American Association of State Highway Officials Standard Specifications for Bridges, 1953 edition, insofar as these specifications can be applied to the design of a suspension bridge. Permissible stresses in cables, factor of safety against sliding of anchorages, required vibrational stiffness (both vertical and torsional) and many other features of suspension bridge design are not covered in the A.A.S.H.O. Specifications. It was therefore necessary to rely on experience and the recommendations of other designers of suspension bridges for limitations and recommendations. In this connection Mr. G. B. Woodruff was consulted and made recommendations with regard to live loads, wind loads, etc. that should be provided for.

The approach spans at the south end of the crossing are unique only in that they are partly on a 4° curve, partly on a spiral and finally approach the suspension bridge proper on tangent. These are girder spans designed for composite action in regions of positive bending moment. The girders are continuous over the supports and have articulation pins and expansion links at points where the girders must change direction as well as in the straight portion of the bridge. The girders were set to take care of the super-elevation of the curved roadway as well as possible but the concrete deck had to take care of the refinements. In all cases the bottom of the deck followed the line of the girder flanges in order to simplify the formwork. In deference to the area served by the bridge where snow removal would be a problem, continuous snow slot grating about 21 in. wide runs the full length of the bridge adjacent to each curb. On the approach spans the guard rail posts require a moment connection which was obtained by breaking the snow slot grating and making a continuous deck and curb section at each post. This was unnecessary on the suspension bridge so the snow slot grating runs continuously where it will not only be useful from the point of view of snow removal but also will improve the wind resisting qualities of the structure.

The suspension bridge design was based on certain requirements, limitations, assumptions and decisions. Some of these were supplied by the Bridge Branch of the Alberta Department of Highways, such as the 27 ft. clear roadway between curbs, the snow slot grating, the 18 in. minimum safety curbs (wide enough for use as emergency sidewalks) and H20-S16-44 highway loading. In addition it was decided that since lane loading would govern on the long spans for the design of the main elements it would be good economy to increase the stringer, floorbeam and approach span capacity to take care of a single heavy load. Alberta with its oil and gas exploration activity is particularly subject to heavy loads. The load selected was one H40-S32 truck plus impact with rear axles spaced at 24 ft., the truck confined to the centre of the bridge and stresses permitted at 125% of basic unit stress. The main cables, towers and stiffening trusses, so far as live load are concerned are designed for H20-S16-44 with no impact. Suspenders and members of the stiffening truss taking suspender or floor truss reactions are designed for H20-S16-44 plus 30% impact. Stringers and floor trusses not governed by the single heavy truck are also designed for H20-S16-44 plus 30% impact. The structure was designed for a lateral wind load of more than 500 lb. per linear foot on the truss, 100 lb. per linear foot on the cables and 200 lb. per linear foot on the live load.

The bridge is designed on the assumption that under dead load only at +30°F the stiffening truss is unstressed. In order to assure this, closure will not be permitted until the dead load is all in place and the temperature is between 30°F and 35°F.

The design load combinations of significance in the design of the superstructure are:

Case I — Dead + Live + Temperature + Impact @ 100% B.U.S.

Case II — Dead + Full Wind @ 125% B.U.S.

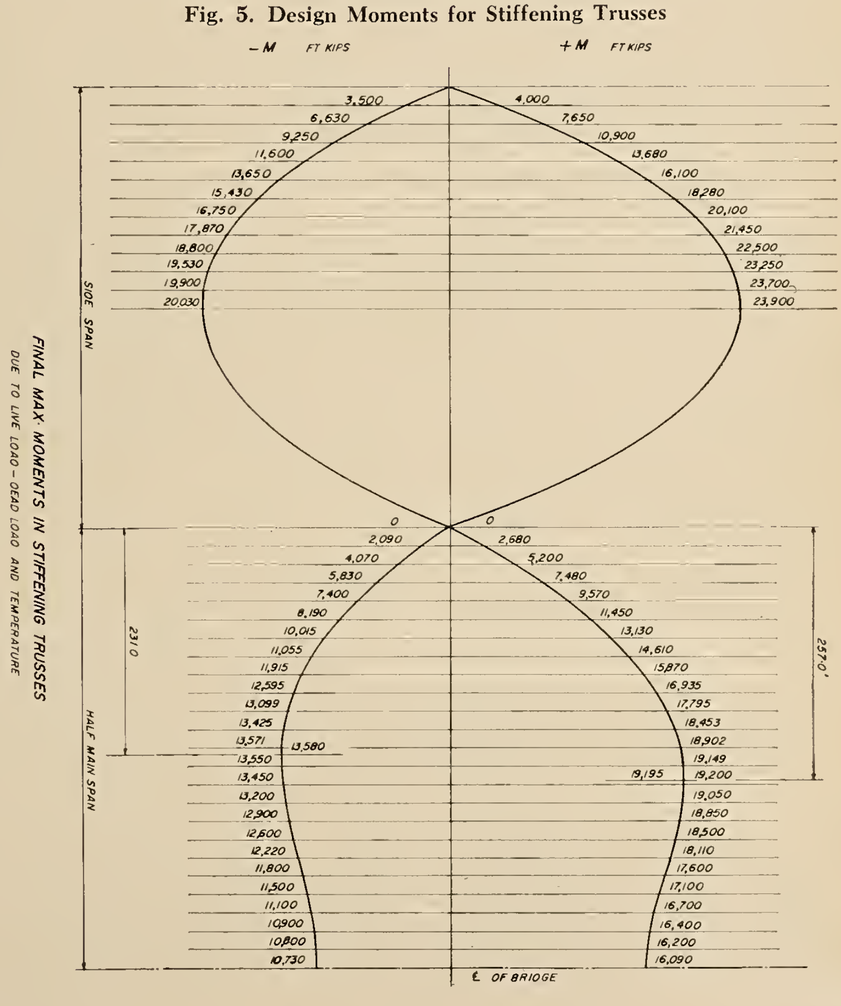
Case III — Case I + 15# Wind + ½ Wind on Live Load + Longitudinal Force for Live Load at 125% B.U.S.

Each main cable for the suspension bridge is made up of 20 — 2⅛ in. bridge strand while the suspenders are 2¼ in. bridge strand. Each 2⅛ in. strand is made up of one 0.207 in. diam. galvanized wire and 90 — 0.193 in. diam. galvanized wire. All wires are full length with no splicing permitted. All strands were required to be prestressed to one-half their specified ultimate strength and held at this load for at least 4 hrs. The tension load was then to be relaxed to the average dead load tension at 30°F and marked for the positions of all hangers, saddles, etc. Actually the suspender locations were marked on only four of the twenty strands since the other strands were erected to match the four guide strands. Modulus of elasticity was determined for each strand and was required to be a minimum of 23.5 x 10^6 p.s.i. Special castings engage the strands and keep them separate at each hanger point. Wooden separators are bolted to the cables mid-way between hanger clamps to stop flutter which could cause fatigue in the outer wires of the strand. Considering the relatively dry climate and the space between strands for air circulation, corrosion of the zinc plated strands is not considered serious. However if inspection in later years shows corrosion is actually occurring there is space enough to apply a corrosion inhibitor.

The structure as a whole has been analysed by the so-called deflection theory first developed by Melan[2] and translated by Steinman.[3] This has been a standard approach to all modern suspension bridge design. The actual analysis was somewhat shortened by following the procedure outlined by Ling-Hi-Tsien[4]. The important constants and other factors necessary for this analysis and belonging to this particular structure are outlined in Appendix 1.

There are several unusual features in the design of this structure which are worthy of discussion. The stiffening truss is a Warren type with double intersecting diagonals and with the wind system and deck at mid-depth. The truss is fairly deep for the relatively short centre span of 900 ft. (short for suspension bridges that is) but there are several good reasons for the choice. Basically it was decided early in the design to attempt to make full use of both top and bottom chords in the lateral wind system. This could only be attained by placing the wind system near mid-depth of the truss. The relatively small towers and narrow sidewalks meant that the hanger cables only clear the roadway by 2½ ft. on either side. It was therefore desirable to keep the upper chord and hence the hanger cables at least five feet above the roadway. These factors led to the choice of a 15 ft. depth of stiffening truss which at 1/60th of the span was considered very satisfactory. The double intersecting diagonals were used to assist in transferring the wind shears to the chords and actually reduce the slenderness ratio of the diagonals to where there is a net saving in weight. The criterion chosen for wind was to limit the lateral deflection to a maximum of three feet under full wind load. Participation between cables and stiffening truss was based on the simplified distribution suggested by Pavlo.[5] A d/l ratio of 1/60 is considered very stiff for suspension bridges but this is particularly desirable when the wind system and deck are at mid-depth rather than at the top or bottom of the stiffening truss. In order to further improve the

Fig. 5. Design Moments for Stiffening Trusses



torsional stability and decrease the wind area floor trusses were used rather than girders.

Analysis of this suspension bridge from the point of view of aerodynamic stability based on Steinman's[6] criteria shows that the mean effective ratio of the distributed force of restitution to the displacement is approximately 450 p.s.f. per cable where he recommends more than 120 p.s.f. for open web stiffening trusses. The ratio per foot of width is approximately 28 lb. per cu. ft. where he recommends not less than six. The proportion of the ratio due to the stiffening trusses is 0.70 where he recommends not less than 0.25. On this basis the aerodynamic stability seems assured. Normally it would be desirable to inhibit relative longitudinal motion between the stiffening trusses and cables at the center of the main span since this is one place where torsional motions can initiate. In view of the exceptional stiffness in all respects of this structure it was decided that this feature was unnecessary. In comparison to the first Tacoma Narrows Suspension Bridge the ratio per cable was about one-seventh that of the Dunvegan Bridge and only 0.015 of this ratio was due to the stiffening girder. The ratio per foot of width of the Tacoma Narrows Suspension Bridge was approximately one-eighth of the Dunvegan Bridge. Compared to the Lion's Gate Bridge the ratio for Dunvegan is about four times as high, the ratio per foot about five times as high and the proportion due to the stiffening trusses about twice as high. This exceptional stiffness was obtained without sacrifice of steel quantities by using the double intersecting Warren system. Fig. 5 and 6 show the bending moments and shearing forces for which the stiffening trusses are designed.

The towers of the Dunvegan Suspension Bridge are unusual in that it was decided to use pinned bases. The reasoning behind this is that in the northern area where the temperature range is ± 80°F from the vertical position of the towers, about twenty percent of the maximum stress in a fixed base tower is due to longitudinal movement of the tower top. A unique approach was also taken to check the stability of the towers. The A.A.S.H.O. establishes permissible unit stresses for compression members on the basis of slenderness ratio. The slenderness ratio cannot be obtained for a tapered column of varying cross-section. On the assumption that the slenderness ratio has significance only from the point of view of decreased stability for

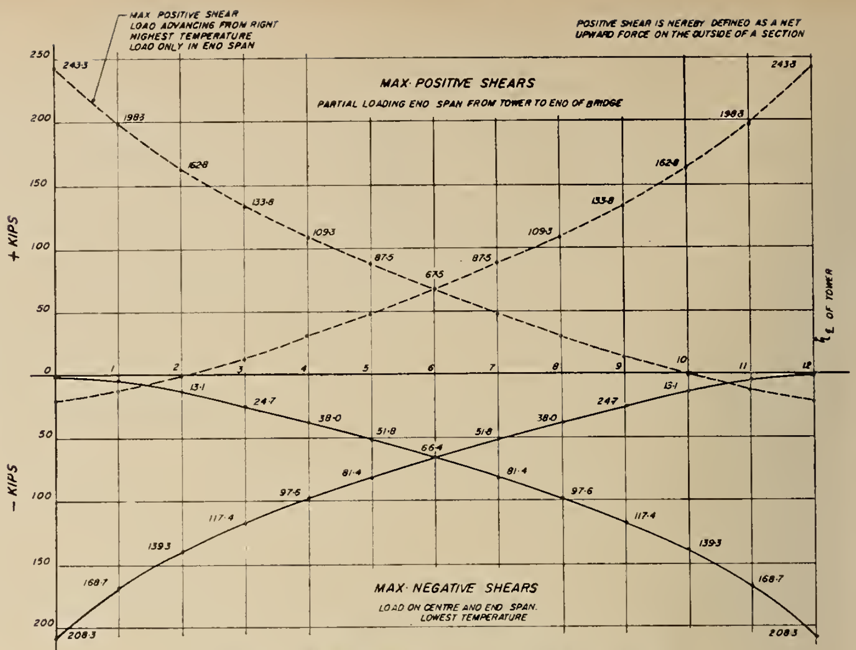


Fig. 6. Design Shears for Stiffening Trusses

greater ratios the problem was approached on the basis of comparing the stability of the tower column with one of the same height and theoretical ultimate capacity but with regular cross-section. The theoretical buckling load for the tower column was computed by means of Newmark's[7] numerical procedures and converted to critical unit stress for the mid-portion of the column. The slenderness ratio of a column of the same length and theoretical buckling stress was then computed and the permissible unit stresses in the tower column reduced the same as would be required by A.A.S.H.O. for the uniform column of equal stability. Although the buckling load on the tower column could never be reached since the yield strength of the steel would be reached first this technique permitted a reduction in permissible load consistent with that which would be required in a uniform compression member of equal stability. Appendix 2 shows a typical calculation for this approach. As it turned out the critical case arose from the combination of direct stress and moment due to lateral forces.

The tower sections were erected in rather unusual fashion by a creeper with a travelling hoist on rails at the top. The roadway on the suspension bridge is set on a camber between towers such that under maximum live load and maximum temperature the deck would theoretically form a straight line between towers. All field assembly is accomplished by high tensile bolting and no field welding has been permitted.

The stiffening truss has been assembled in 37 ft-6 in. sections at the site and will be erected one section at a time. Articulation is to be provided by loose bolting the chords at 75 ft. intervals while pouring the deck and the last work required will be tightening up the gussets at these points.

The Dunvegan Bridge is scheduled for opening in the fall of 1960, and at the time of writing this schedule appears likely to be met. The fabrication is complete on all steel; the towers, cables and hangers are in place and the schedule called for the stiffening trusses to be lifted from the ice to their position in the structure starting the last week of January, 1960. This schedule has been met and at the time of writing it appears certain the structure will be ready for deck forming to commence by March 1, 1960. Fig. 7 shows some progress photos taken during erection of the stiffening trusses. Forming and pouring the concrete and asphalt deck will take most of the summer with closure of the articulation points and paint touch-up the last operation.

Conclusions

The Dunvegan Suspension Bridge is Alberta's longest clear span and the fourth largest suspension bridge in Canada. The use of a suspension bridge for the relatively short clear span of 900 ft. might be considered marginal but the cost of the crossing and the quantities of materials used have justified the choice. The superstructure of the suspension bridge contains 2620 tons of structural steel and 509 tons of cables and fittings. Cables and fittings cost approximately fifty percent more than structural steel in the suspension bridge proper. The snow slot grating, the extra structural steel required due to the grating and the extra steel in the stringers and floor trusses due to the single heavy truck amount to approximately 350 tons which reduces the equivalent quantity of steel to approximately 3,000 tons. Comparison with other structures is difficult, because design requirements and class of structure enter the picture. The structural steel quantity of 0.83 tons per lane per foot of bridge is almost identical with the quantity in the former Taylor Flats Suspension Bridge. This structure however was designed for only H15-S12 live loading and a lateral wind force of 270 lb. per ft. which is less than half that provided for in the Dunvegan design. Other structures with similiar clear spans appear to run between 0.85 and one ton per lane per foot of span depending on location, facilities provided and class of structure. The overall cost of the crossing including the 575 ft. of approach span will be approximately $4.5 million which compares favourably with other projects of a similar nature in the same general area.

APPENDIX 1

Design Constants

The stiffening trusses were analyzed by the Deflection Theory using the simplified methods of Ling-Hi-Tsien.[4] The numerical values from which the constants were computed together with the constants which apply to this structure are presented using the nomenclature of his paper, as a matter of interest. Finally Fig. 6 and No. 7 show the design values of maximum moment and maximum shears for which the stiffening trusses were designed.

Fig. 7. Floor Trusses together with the stiffening trusses and cables, looking south through the middle of the bridge

Given

$l = 900$ ft.

$l_1 = 450$ ft.

$f = 100$ ft.

$f_1 = 25$ ft.

$EI = 26.15 \times 10^7$ ft.^{2} Kips

$EI_1 = 26.07 \times 10^7$ ft.^{2} Kips

$A = 2.675 \times 40 = 107.0$ in.^{2}

$\Delta T = \pm 80°F$

$n = \frac{f}{l} = \frac{100}{900}$

$n_1 = \frac{f_1}{l_1} = \frac{25}{450}$

$p = 1.28K/\text{ft.}$

$w = 5.4K/\text{ft.}$

Summary of Constants

$w = 5.4K/\text{ft.}$

$H_w = 5465K$

$B = 1.567$

$B_1 = 3.261$

$C_0^2 = 20.91 \times 10^{-6}/\text{ft.}^2$

$C_{01}^2 = 20.96 \times 10^{-6}/\text{ft.}^2$

$N_s = 0.1231$

$N_c = 0.1509$

$N_T = 0.02125$

$T = 0.1404$

$S = 0.0581$

$C_0^2 l^2 = 16.93$

$C_0 l = 4.12$

$\frac{pl^2}{8f} = 1296K$

$\frac{pl^2}{8fD + t} = 1000K$

$\frac{pl^2}{8fD - t} = 1034K$

$p = 1.28K/\text{ft.}$

$q = 0.2370$

$n = 1/9$

$n_1 = 1/18$

$r = 0.5$

$D + t = 1.2953$

$D - t = 1.2527$

$EI = 26.15 \times 10^7$ ft.^2K

$EI_1 = 26.07 \times 10^7$ ft.^2K

$C_{01}^2 l_1^2 = 4.24$

$C_{01} l_1 = 2.06$

APPENDIX 2

Tower Design

The towers may be considered as pinned top and bottom in the longitudinal direction with unsupported length from the base pin to the P.I. of the cables. In the lateral direction the columns are continuous and have lateral support as individual members at each of the cross beams. The loading cases, discussed in the test are

Case I — Dead + Live + Temperature + Impact @ 100% B.U.S.

Case II — Dead + Full Wind @ 125% B.U.S.

Case III — Case I + 15# Wind + ½ Wind on Live Load + Longitudinal Force from Live Load @ 125% B.U.S.

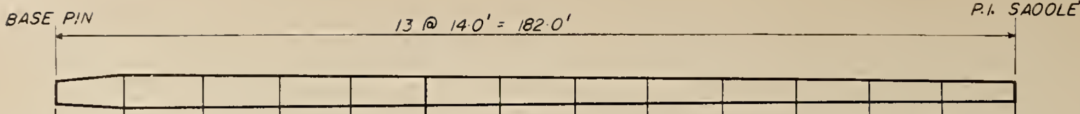
in which B.U.S. stands for Basic Unit Stress.

The stability of the towers needs to be investigated in the direction of the span under Case I loading while the stability perpendicular to the span will depend on Case II or Case III loading. Case II loading gave the worst combination of direct stress and bending in a lateral direction of the tower and the sections were selected to satisfy this condition. For example the section of south tower between the bottom strut and rocker beam carries end moments of +4150 ft. kips and -2702 ft. kips together with an axial load of 3210 kips. When designed according to Appendix "B" of the A.A.S.H.O. this section would require 338 sq. in. at 9.5 k.s.i. (125 x B.U.S. of 7.6 k.s.i.).

The final choice of section based on considerations throughout the length of the tower resulted in a constant section with an area of 398 sq. in. throughout the middle portion of the tower with constant depth perpendicular to the span and with the ends tapered in the other direction.

An analysis of this tower to determine the theoretical critical buckling load for one leg (see Fig. 8) using Newmark's[7] numerical procedures shows after three successive rounds that the theoretical critical buckling load is close to 16,400 kips. A uniform column of equal length, area and stability would have a slenderness ratio of 84.5. According to A.A.S.H.O. such a column would have a permissible unit stress in axial compression of 12.6 k.s.i. Since this is greater than the 9.5 k.s.i. required for the combination of loads under Case II the latter was the governing case.

The foundation investigation and recommendations were under the supervision of Dr. R. M. Hardy and the precautions against scour were based on the recommendations of Dr. T. Blench of the University of Alberta. C. B. Woodruff of San Francisco was consulted regarding suspension bridge design in general and recommended live and wind loads. G. D. Morrison and R. M. Morison, resident engineers on the substructure and superstructure respectively have played important parts in the success



SECTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
EI	1·78	4·50	4·50	4·50	4·50	4·50	4·50	4·50	4·50	3·10	2·39	1·76	1·27	1·00	21.4×10^8 in.^{2} K
Ya	0	1	2	3	4	5	6	7	7	6	5	4	2	0	in·
M	0	1	2	3	4	5	6	7	7	6	5	4	2	0	P_{cr} in·K
α	0	-0·222	-0·445	-0·667	-0·889	-1·111	-1·333	-1·556	-1·556	-1·935	-2·092	-2·273	-1·575	0	$\frac{P_{cr}}{21.4\times10^8}$ RAD/in·
ᾱ		-2·665	-5·339	-8·004	-10·67	-13·33	-15·99	-18·45	-19·05	-22·99	-25·13	-26·40	-18·02		$\frac{P_{cr}\times14\times12}{21.4\times10^8\times12}$ RAD
θ	72·0	69·34	63·99	55·99	45·32	31·99	16·00	-2·45	-21·50	-44·49	-69·62	-96·02	-114·04		
Yb	0	72·00	141·3	205·3	261·3	306·6	338·6	354·6	352·2	330·7	286·2	216·6	120·6	6·5	$\frac{P_{cr}\times14\times14\times12}{21.4\times10^8}$ in·
Yc	0	-0·50	-1·00	-1·50	-2·00	-2·50	-3·00	-3·50	-4·00	-4·50	-5·00	-5·50	-6·00	-6·50	
Yf	0	71·50	140·3	203·8	259·3	304·1	335·6	351·1	348·2	326·2	281·2	211·1	114·6	0	
Yf	0	1·00	1·96	2·85	3·63	4·25	4·69	4·91	4·87	4·56	3·93	2·95	1·60	0	$\frac{71.5\times P_{cr}\times14\times14\times12}{21.4\times10^8}$ in·

$$P_{cr} = \frac{52.00}{41.20} \times \frac{21.4\times10^8}{71.5\times196\times12} = \underline{\underline{16{,}100^K}}$$

SECTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
M	0	1·00	1·96	2·85	3·63	4·25	4·69	4·91	4·87	4·56	3·93	2·95	1·60	0	P_{cr} in·K
α	0	-0·222	-0·436	-0·633	-0·807	-0·944	-1·042	-1·091	-1·082	-1·471	-1·644	-1·676	-1·260	0	$\frac{P_{cr}}{21.4\times10^8}$ RAD/In·
ᾱ		-2·656	-5·215	-7·573	-9·647	-11·29	-12·46	-13·03	-13·38	-17·44	-19·59	-19·66	-14·28		$\frac{P_{cr}\times14\times12}{21.4\times10^8\times12}$ RAD·
θ	62·84	60·19	54·97	47·40	37·75	26·46	14·00	0·97	-12·41	-29·85	-49·44	-69·10	-83·38		
Yb	0	62·84	123·0	178·0	225·4	263·2	289·6	303·6	304·6	292·2	262·3	212·9	143·8	60·40	$\frac{P_{cr}\times14\times14\times12}{21.4\times10^8}$ in·
Yc	0	-4·65	-9·30	-13·94	-18·59	-23·23	-27·88	-32·52	-37·17	-41·82	-46·46	-51·11	-55·76	-60·40	
Yf	0	58·19	113·7	164·1	206·8	240·0	262·3	271·1	267·4	250·4	215·8	161·8	88·0	0	
Yf	0	1·00	1·95	2·82	3·55	4·12	4·51	4·66	4·60	4·30	3·71	2·78	1·51	0	$\frac{58.19\times P_{cr}\times14\times14\times12}{21.4\times10^8}$ in.

$$P_{cr} = \frac{41.20}{39.51} \times \frac{21.40\times10^8}{58.19\times196\times12} = \underline{\underline{16{,}300^K}}$$

SECTION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
M	0	1·00	1·95	2·82	3·55	4·12	4·51	4·66	4·60	4·30	3·71	2·78	1·51	0	P_{cr} in·K
α	0	-0·222	-0·433	-0·627	-0·789	-0·916	-1·002	-1·036	-1·022	-1·387	-1·552	-1·580	-1·189	0	$\frac{P_{cr}}{21.4\times108}$ RAD./in·
ᾱ		-2·653	-5·179	-7·492	-9·433	-10·95	-11·97	-12·38	-12·64	-16·44	-18·49	-18·54	-13·47		$\frac{P_{cr}\times14\times12}{21.4\times10^8\times12}$ RAD·
θ	56·67	54·02	48·84	41·35	31·92	20·97	9·00	-3·38	-16·02	-32·46	-50·95	-69·49	-82·96		
Yb	0	56·67	110·7	159·5	200·9	232·8	253·8	262·8	259·4	243·4	210·9	160·0	90·5	7·53	$\frac{P_{cr}\times14\times14\times12}{21.4\times10^8}$ in.
Yc	0	-0·58	-1·16	-1·74	-2·32	-2·90	-3·48	-4·06	-4·64	-5·22	-5·80	-6·38	-6·96	-7·53	
Yf	0	56·09	109·5	157·8	198·6	229·9	250·3	258·7	254·8	238·2	205·1	153·6	83·5	0	
Yf	0	1·00	1·95	2·82	3·54	4·10	4·46	4·61	4·54	4·25	3·66	2·74	1·49	0	$\frac{56.09\times P_{cr}\times14\times14\times12}{21.4\times10^8}$ in

$$P_{cr} = \frac{39.51}{39.16} \times \frac{21.4\times10^8}{56.09\times196\times12} = \underline{\underline{16{,}400^K}}$$

Fig. 8. Theoretical Critical Buckling Load, South Tower — One Leg.

of the project. P. G. A. Brault and R. E. Chamberlain of Dominion Bridge Co., were very helpful in reviewing the design and details prior to fabrication.

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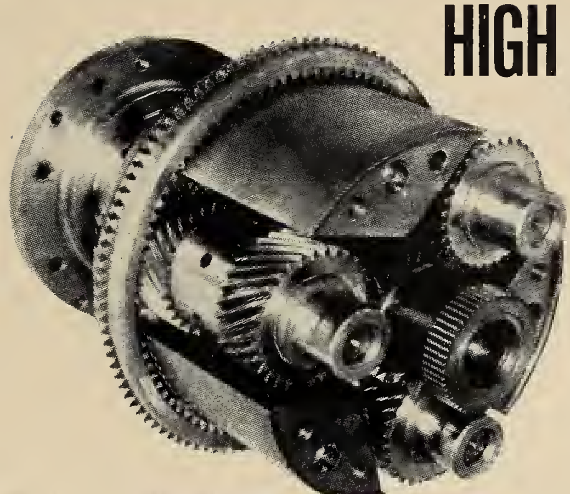
MARINE AND INDUSTRIAL HIGH POWERED EPICYCLIC GEARING



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Shortly after the war, great interest was aroused in work which had been taking place in Germany on epicyclic gearing designed to the principles of Dipl.-Ing. W. Stoeckicht of Munich. Work commenced in England on gearing to these principles in 1946 and a paper was written on the subject by the authors in 1952. At that time there were critics and doubts were expressed in many quarters concerning these developments. This paper, presented eight years later, describes the rapid progress which has in fact taken place in the application of epicyclic gearing for use in high speed, high torque and high powered applications, and is based upon highly successful results. The gearing described is equally suitable for speed reducing or speed increasing applications and attention is drawn to developments for speed change, reduction-reverse and for de-clutchable applications. The use of combined co-axial and parallel axis gearing is discussed. Reasons are given for such gearing to be able to deal with high speeds and torques without exceeding recognised maximum permissible tooth speeds and stresses. An unusual form of hardening the toothed components is described with reasons for its adoption. Results are compared with those obtained by the more usual carburising method. The paper is illustrated with reference to many different types of installation and application.

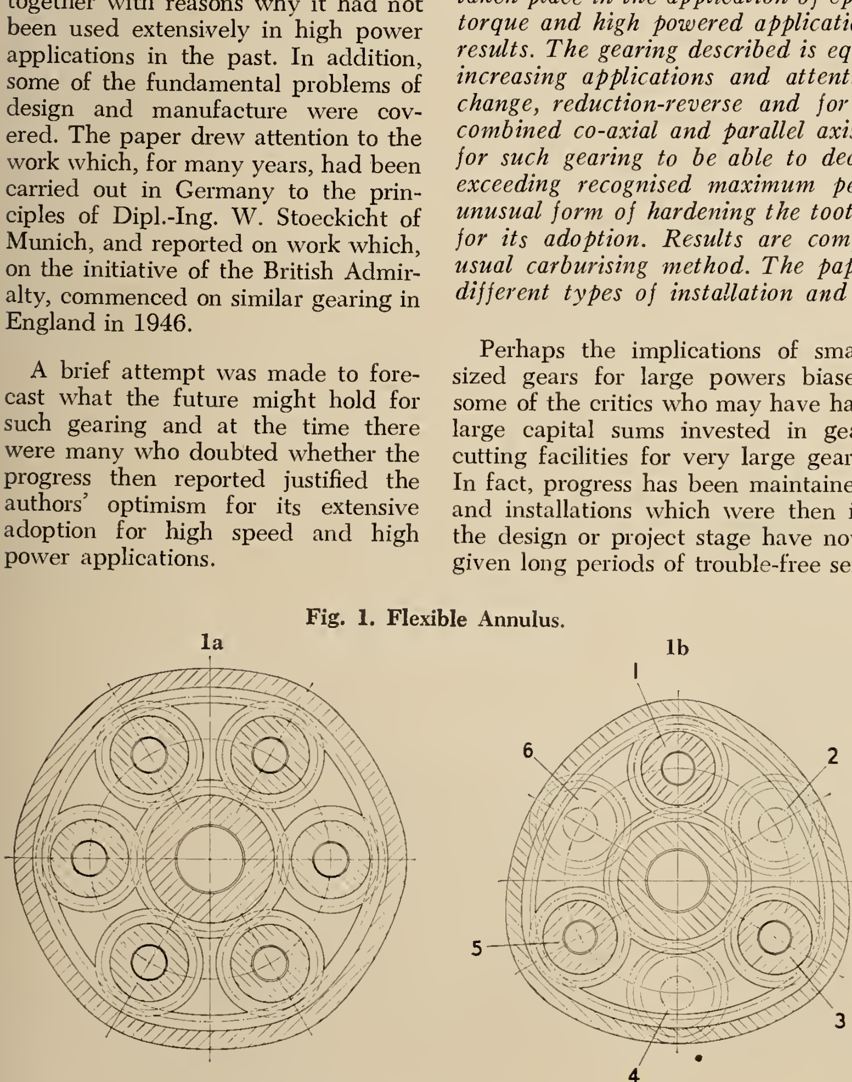
EIGHT YEARS ago the authors presented a paper to the Institute of Marine Engineers in London, England,[1] outlining many types of epicyclic gearing for industrial and marine applications. A brief historical survey of epicyclic gearing was given, together with reasons why it had not been used extensively in high power applications in the past. In addition, some of the fundamental problems of design and manufacture were covered. The paper drew attention to the work which, for many years, had been carried out in Germany to the principles of Dipl.-Ing. W. Stoeckicht of Munich, and reported on work which, on the initiative of the British Admiralty, commenced on similar gearing in England in 1946.

A brief attempt was made to forecast what the future might hold for such gearing and at the time there were many who doubted whether the progress then reported justified the authors' optimism for its extensive adoption for high speed and high power applications.

Perhaps the implications of small sized gears for large powers biased some of the critics who may have had large capital sums invested in gear cutting facilities for very large gears. In fact, progress has been maintained and installations which were then in the design or project stage have now given long periods of trouble-free service. A great deal of what was described has become even more firmly established practice. It is thought that the present paper which reports on some of the many successful applications which have taken place may be of wide interest because it shows not only that doubts which have been expressed about the suitability of such gearing for high power applications have proved to be unfounded but also indicates that further developments are to be expected.

The authors have tried to give what they consider to be an unprejudiced view of interesting and significant developments in epicyclic gearing, and hope that what they have to say may be strengthened by the fact that they still maintain an interest in the type of gearing which was formerly used in many of the applications quoted, and which still has an important part to play. All forms of gearing are but a means to an end, and each application needs to be engineered according to the merits of the case.

Fig. 1. Flexible Annulus.



Growth in Size and Numbers of Double Helical Epicyclic Gears

In any type of gearing the advantages to be gained from the use of helical teeth, compared with spur teeth, for the transmission of large powers are well-known. Amongst them, particularly in high speed applications, one of the more important is that of noise. It is found almost invariably that high speed gearing with helical teeth is quieter than gearing made with spur teeth. In many cases the use of double helical, as distinct from single helical, gearing is considered desirable.

Stoeckicht gears in which the sunwheel has no bearings have been successfully made with spur and single helical teeth, but the use of double helical gearing gives further advantages from this point of view. There is a better support for the floating sunwheel because the radial components of the tooth forces act in two separate planes and the equal and opposite axial forces on the sunwheel teeth also tend to have a steadying influence. Further, there is no tipping moment—as would be the case with single helical gears—to be resisted by the planet wheel bearings.

It is not surprising, therefore, that the most rapid and extensive progress with Stoeckicht gearing has been made with the double helical form which was introduced some ten years ago. This type has proved to be much more suitable for the majority of industrial and marine applications than earlier forms of epicyclic gearing using spur or single helical teeth. The paper amplified some of the reasons for the rapid growth in the use of such gearing from 1951 to the end of 1959.

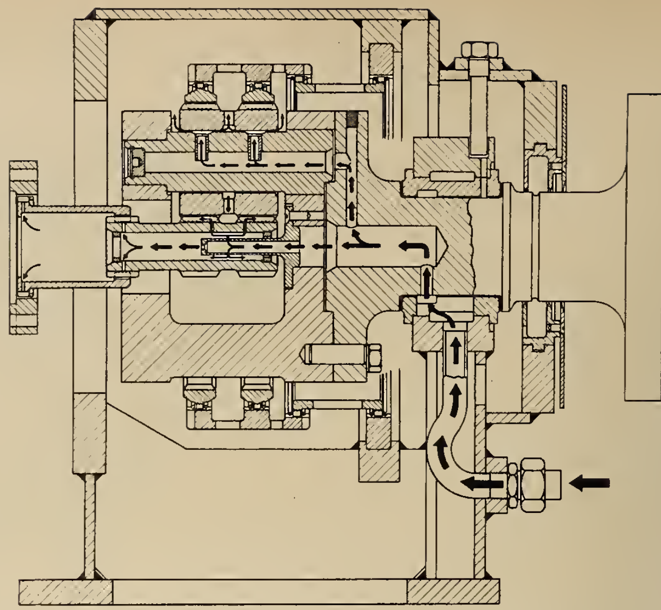


Fig. 4. Sectional Arrangement of a Typical Epicyclic Gear showing Flow of Lubricating Oil.

In 1951 there were very few applications and the total horsepower involved was quite small, but by the end of 1959 there were 2050 applications with a total horsepower of more than 4,400,000. This is an average of 2100 hp. for each gear, but in fact the powers vary from just over 100 hp. to 20,000 hp. The input speeds vary from a few revolutions per minute up to 45,000 r.p.m., but even in the gears with high input speeds the pitch line velocity is relatively low as this is, of course, one of the inherent advantages of epicyclic gearing.

The gears include speed-reduction and speed-increasing gears, change-speed gears, reduction-reverse gears and also de-clutchable gears. There is a wide variety of industrial and marine applications, and a number of these will be described in some detail in this paper in an attempt to illustrate the extensive field in which high power epicyclic gearing is now playing a part.

Mechanical Considerations

The Importance of Load Sharing between Planet Wheels: The main difference between parallel shaft gearing and epicyclic gearing is that, in

Fig. 2. Load Sharing Between Planet Wheels.

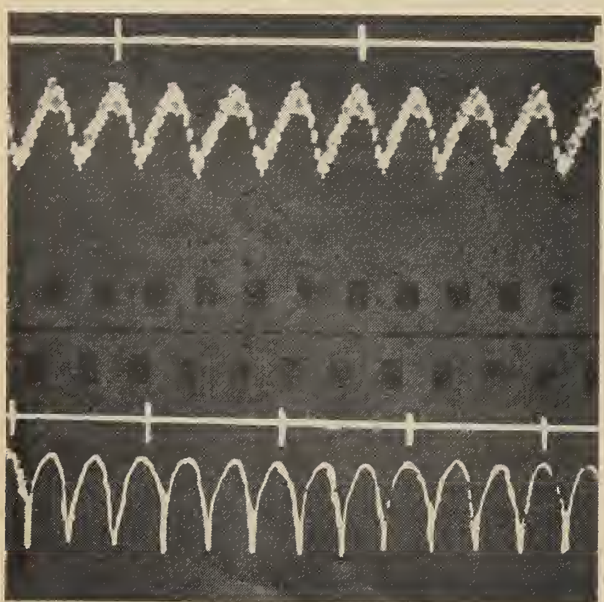


Fig. 3. Principal Components.

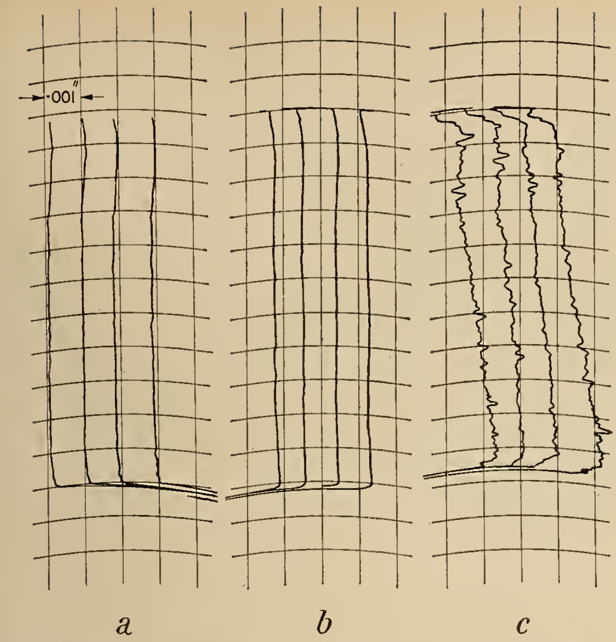


Fig. 5. Check Results on Helix Angle of Carburised and Nitrided Wheels.

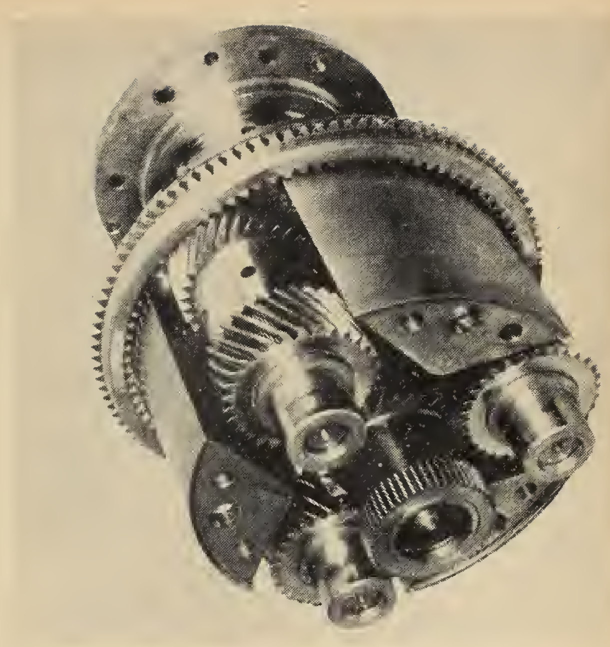


Fig. 6. 1450 hp. Double Helical Epicyclic Gear, Using Hardened and Ground Planet Wheels.

the latter, the load is transmitted by more than one set of tooth contacts, but in order to take advantage of this, it is, of course, essential to ensure that the load is equally divided between all planet wheels. It may not be out of place to re-state the now well-known Stoeckicht principles for ensuring automatic load sharing, as these are so essential for the success of large power epicyclic gearing. This recapitulation of the principles may be particularly desirable as other attempts have been made, without their use, which have not been so successful.

It is easy to understand that if torque is applied to an epicyclic gear with three planet wheels whilst it is prevented from rotating, and one of the co-axial members, either the sunwheel or the annulus or the planet carrier, is allowed to float, the tooth forces involved will move the floating member until equilibrium is obtained. It is not possible, however, to demonstrate this feature theoretically when more than three planet wheels are used. Moreover, under running conditions the problem becomes more complicated, particularly as it is impossible to manufacture components which are perfectly accurate. However, experience has shown that the problems involved can be overcome and the following free translation from a paper by Barwig[2] amplifies these points with particular reference to double helical gears.

"In parallel shaft double helical gearing the gears are usually located axially by one of the wheels, and because this wheel is fixed axially the inertia forces which arise from unavoidable tooth errors, and which work against equal loading between the helices, may sometimes be greatly increased even at moderate speeds. In double helical Stoeckicht gearing, one of the two co-axial members, usually the annulus, is made divided. There are two identical single helical annuli with opposite helix angles which are connected together and to the torque reaction member by means of gear-toothed couplings. The freedom achieved by these means ensures uniform division of the load between both helices, undisturbed by additional dynamic forces. Balancing achieved by these means is not enough in itself when more than three planet wheels are used, nor at very high speeds. Therefore, as an additional measure, allowance is made for a predetermined elastic deformation of the annulus under load. This is achieved by correctly dimensioning the annulus, and Fig. 1a shows a section through a Stoeckicht gear with six planet wheels. The figure gives an exaggerated indication of the elastic deformation of the annulus. This annulus would be freely connected to the torque reaction member by means of a gear-toothed coupling not shown in the figure.

Since free suspension of the annulus is generally sufficient for equal load sharing between three planet wheels, it is arbitrarily assumed that due to tooth errors only three planet wheels (1, 3, and 5) are sharing in the transmission of power. Immediately the radial components of the circumferential forces try to bend the annulus into the form of a triangle as shown in Fig. 1b. As a result of this the annulus approaches the planet wheels (2, 4 and 6), which so far have not been in engagement. In them, the backlash which was formerly too great, is reduced, whilst in the remaining wheels the backlash is at the same time increased. Since all the errors occurring in epicyclic gears, including the pitch and concentricity errors of the planet carrier, eventually affect the toothed components, the problem to be overcome is the elimination of the effects of the errors which periodically add up to a maximum. This difficulty is overcome by making the annulus with the requisite degree of flexibility."

As evidence that a freely supported annulus with the requisite degree of flexibility does, in fact, ensure equal load sharing, Fig. 2 shows oscilloscope readings of strain gauges fitted to annulus systems with three and four planet wheels. Successive peaks on the graph indicate the strain induced in the annulus by successive planet wheels passing the same point. Perhaps even more conclusive evidence comes from the very large number of Stoeckicht gears which have now given long periods of entirely trouble-free service. The number of planet wheels which may be used is dependent on the gear ratio, and although in practice gears using up to eight planet wheels have proved quite satisfactory, in the majority of installations only three are used.

Manufacturing Advantages arising from Reduction in Size and in the Use of Internal Teeth: So much for the fundamental necessity of ensuring that the planet wheels share the load. Once this is established, advantage may be taken of the fact that more than one set of toothed components is used in the transmission of power to give considerable reductions in the size of gearing needed for any given application.

The reduction in size which is possible makes it easier to control accuracy in the manufacture of gear components. It is also helpful in considering the use of hardened sun and planet wheels, and all the epicyclic gearing, to which reference is made in this paper, takes advantage of this fact.

If one considers a 10 : 1 ratio conventional parallel shaft gear, the wheel would be ten times as large as the pinion, but in a planetary gear for the same ratio the planet wheel is only four times the size of the sunwheel. The sunwheel itself would be smaller than the pinion of a parallel shaft gear for the same duty, because instead of just one set of tooth contacts being usefully employed three would be used. In other words, in the epicyclic gear the largest gear wheel to be hardened is only four times as large as the smallest, compared with ten times in the case of the parallel shaft gear.

The surface stress between internal and external teeth running together is less than that between external teeth. It is, therefore, usually unnecessary to harden the annulus when taking advantage of the use of hardened sun and planet wheels. A further important consideration in design is that the internal teeth of the annulus are stronger in bending than would be corresponding external teeth in a wheel of similar size. The annulus, therefore, may be made in material of a lower tensile strength than that of the material in which the sun and planet wheels are made.

Principal Components: The principal components of a high power Stoeckicht gear are illustrated in Fig. 3. The teeth of the wheels are, of course, most important and must be correctly designed and manufactured, but it is also essential to make sure that the planet carrier is made accurately and that the planet wheels spindles are correctly spaced. The planet carrier is of particularly robust construction.

Fig. 4 shows a cross sectional arrangement of these components assembled to form a complete gear.

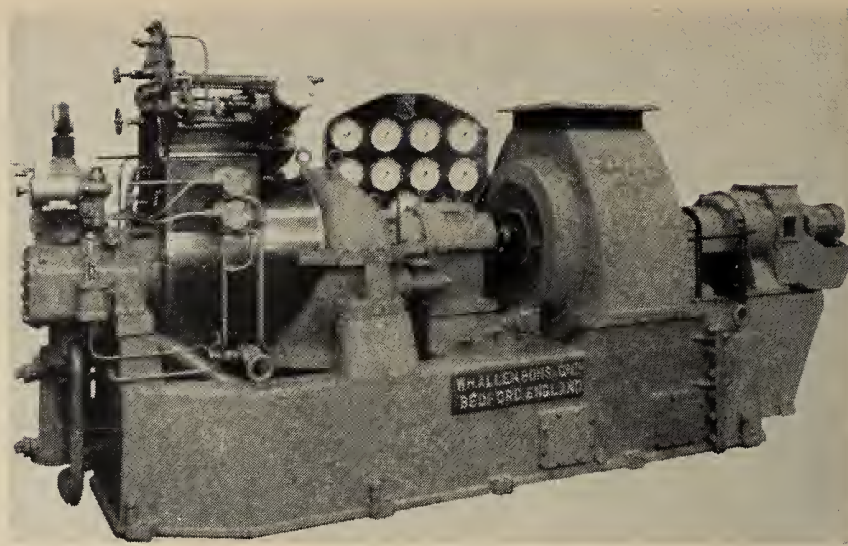
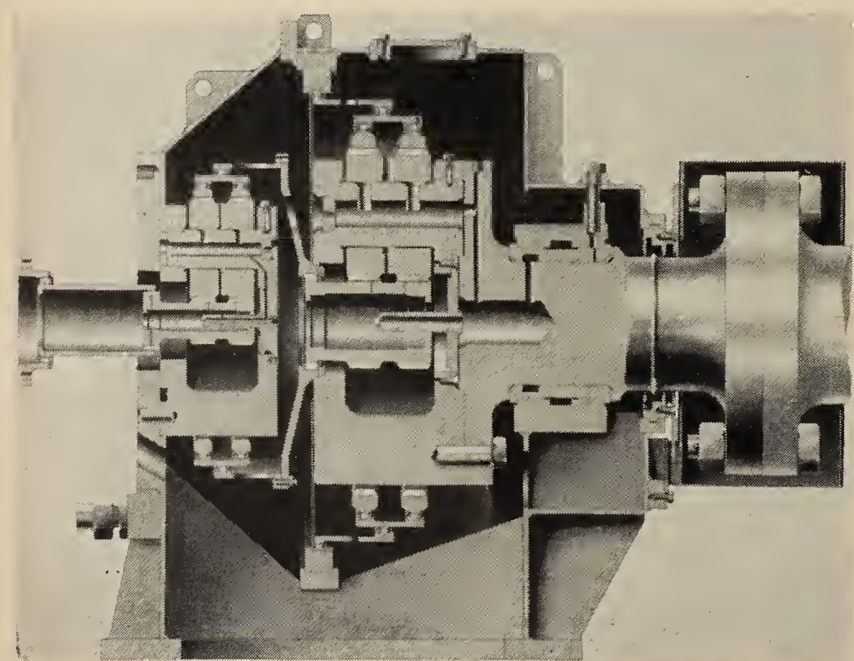


Fig. 8. Turbo-Alternator for C.S.L. *Fort Henry.*

Reference has already been made to the fact that all the epicyclic gears mentioned in this paper use hardened sun and planet wheels, and over 95% of them have these components hardened by the nitriding process (See Appendix II). A great advantage of this method of hardening, compared with others, is that virtually no distortion takes place during hardening, and it is unnecessary to carry out any post-hardening correction processes on the teeth. Fig. 5a, b and c illustrate check results (from a Maag P.H. 60 measuring machine) on the helix angle of two identical components each having 21 teeth of 8 d.p. and a face width of 2 in. Tests of profile, carried out on the same machine gave similar results. Fig. 5a shows the result obtained on a nitrided wheel after nitriding. Fig. 5b is a check from a similar wheel before hardening by the normal pack carburising method. Fig. 5c is the same wheel after carburising and quenching. It will be apparent immediately that whereas Fig. 5a shows a wheel which will be quite suitable for use and is, in fact, very good, it would be essential to grind the wheel which is illustrated in Fig. 5c before it could be put into service. Grinding is a long and expensive process. The nitriding steel used by the authors gives a surface hardness similar to that obtained by pack carburising and, although the case depth of the nitrided wheel may be less than that of the carburised wheel, in practice it has always been found adequate.

Fig. 7. 27:1 500 hp. Double Reduction Gear 16,500/600 r.p.m. Largest Annulus Diameter 14 in.



No radial or transverse forces from epicyclic gears act on the gearcase except the torque reaction which may be taken up on the circumference of the gearcase. Stresses on the casing arising from outside sources cannot affect the tooth contacts unfavourably. This is particularly important in marine applications where it is sometimes difficult to ensure that the gear casing will be completely free from stresses and deflections induced by the hull. The fact that the gearcase is small and, therefore, can be much stiffer than the considerably larger case needed for parallel shaft gearing is, of course, a further advantage.

The planet wheel bearings of an epicyclic gear are particularly interesting and in most cases the best bearing is obtained by using a spindle faced with white metal on which the planet wheels rotate. This form of bearing has several advantages, amongst which is the fact that the load on the white metal is always in the same direction and consequently there is less chance of the bearing failing by fatigue than if a bush lined with white metal were used in the wheel. When a white metal facing is used it is possible to finish the bore of the wheel before the teeth are finished and this makes it easier to ensure that the teeth are true with the bore. Examination of spindles of this type made after 33,000 hours running shows no sign of wear.

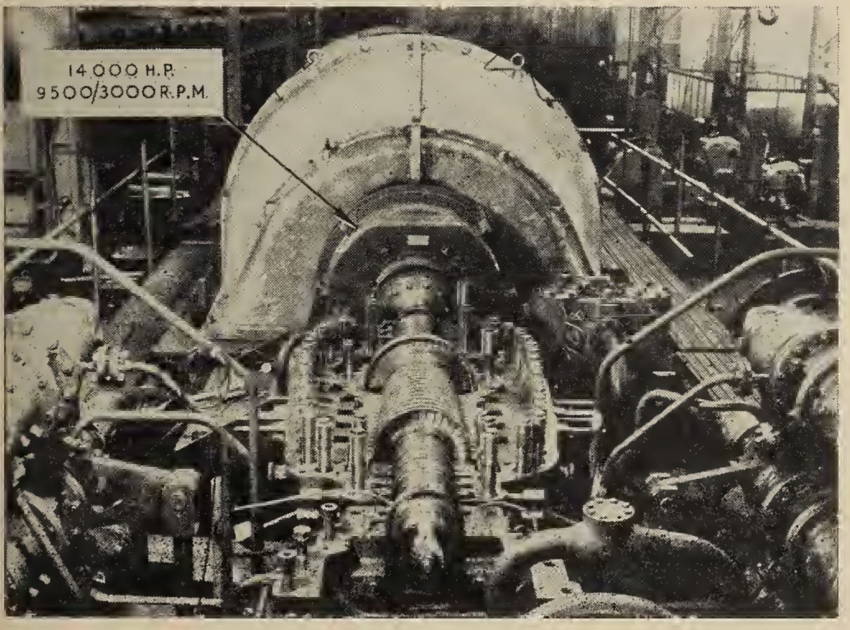
Lubrication: The arrows in Fig. 4 illustrate the method of lubricating a typical epicyclic gear. The planet wheel bearings are fed with oil led into the centre of the low speed shaft and then by radial holes via the centre of the planet wheel spindles, to the bearings. The sun-wheel/planet contacts are lubricated by oil led into the centre of the sun-wheel, from which it flows by radial holes in a number of tooth spaces, the planet/annulus contacts by the oil mist present in the gearcase and the gear tooth type flexible coupling by radial holes in each tooth space. Precautions are taken in gears where the planet carrier revolves to see that any sludge in the lubricating oil is retained inside the spindle and not allowed to centrifuge out onto the planet wheel bearing surfaces. The bores of the spindles may be cleaned during periodical inspection of the complete unit.

The gear may be lubricated either by means of filtered oil from the prime mover lubricating oil system, or by oil supplied by a pump mounted on the casing, and driven through gearing from the low speed shaft. Where the authors have freedom of choice, normal geared-turbine oils with no special extreme pressure additives are used. However, in order to avoid the necessity for various oils in an installation, it is usually found possible to use whatever oil is required by the prime mover.

Efficiency: Epicyclic gearing is at least as efficient as parallel shaft gearing, and a number of factors which are inherent in epicyclic gearing make it even slightly better. In applications where the planet carrier revolves, the relative pitch line velocity between the sun and planet wheels is reduced and this leads to an increase in efficiency in the tooth engagements. The elimination of bearings completely from the high speed rotating member removes the most prolific sources of loss in any form of gearing. In fact, with epicyclic gears the losses in some cases may be as little as half those with parallel shaft gears.

Accessibility: Epicyclic gears are sometimes criticised as being inaccessible compared with parallel shaft gears, and it is true that on lifting the top cover of an epicyclic gear very little can be seen of the principal components. However, it is easily possible to arrange such gearing so that the whole rotating assembly can be conveniently removed without affecting the alignment of the bearings of the driving or driven machines. Once the rotating assembly has been removed it can quickly and easily be dismantled completely. Having done this, it is, in fact, easier to examine the teeth and planet wheel bearings in greater detail than is sometimes possible with the teeth and bottom half bearings of large parallel shaft gears.

Fig. 9. Super-critical Steam Turbine Incorporating 14,000 hp. Epicyclic Gear to give a Speed Reduction from 9500 to 3000 r.p.m.



Co-axial and Parallel Shaft Arrangements: Not only are reductions in size obviously advantageous from the point of view of savings in weight and space and ease of handling, but also the co-axial arrangement of input and output shafts often leads to an improved arrangement of machinery installation. However, it is clear that a co-axial arrangement of the shafts does not always meet requirements, and in installations where a change of centre between driving and driven members is desirable, parallel shaft gears are obviously more suitable than epicyclic gears. Moreover, there are a number of applications where a combination of epicyclic gears with parallel shaft gears can give the best answer for the overall requirements of the installation. One example will be given later in this paper, and it is possible that in the future further advances will be made in the combination of both types of gearing, to the overall improvement of the complete installation, particularly for the propulsion gearing of large power Merchant and Naval vessels.

Epicyclic gearing can be used most conveniently for reversing, and can be useful in cases (such as manoeuvring in icy conditions) where it is sometimes desirable to be able to de-clutch the engine from the propeller shaft. A most important aspect where changes of speed or direction or rotation are concerned is that not only have the rotating parts of epicyclic gearing a lower weight, but also their inertia is much reduced. An example illustrating this reduction of inertia is given later, where the gears being compared both use hardened components and have comparable specific loads.

Representative Applications

Gas Turbines: It was not surprising that when Stoeckicht double helical gears were first introduced they were regarded with suspicion by some engineers. This was natural as previous attempts to introduce high power epicyclic gearing had not been successful. This form of gearing had established itself firmly in the automobile and aircraft industries, but in aircraft there had been considerable difficulties.

However, at the time many gas turbine designers were pioneers, ap-

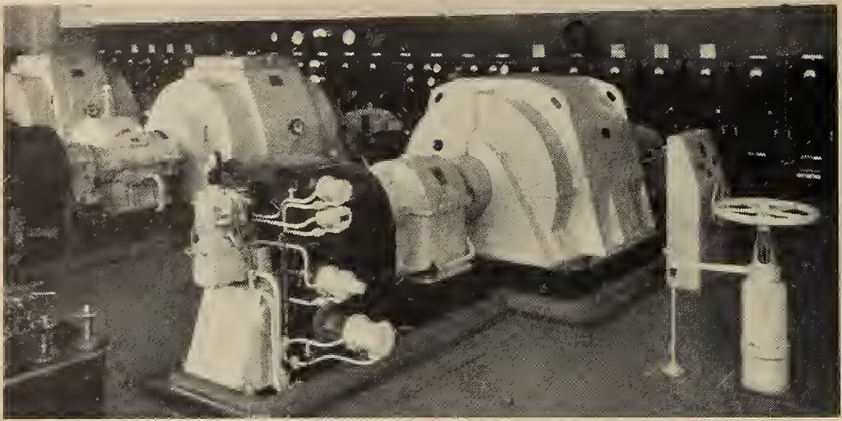


Fig. 10. Turbo-Alternator Incorporating 5000 hp. Epicyclic Gear giving a Reduction Ratio from 9500 to 1500 r.p.m.

plying aircraft techniques to industrial and marine fields, and some were quick to appreciate the advantages of a compact gear scientifically designed and accurately made and furthermore generally in keeping with their own advanced engineering thought and action. Their foresight with regard to epicyclic gears proved correct and they have been able to fit and forget them.

Fig. 6 illustrates the basic rotating elements of a gear designed for the Ruston and Hornsby T.A. 1450 hp. unit which has had over ten years' experience. 125 of these units have been supplied for service all over the world, some in oil pumping installations in the Middle East operating under very primitive conditions. The illustration shows clearly the excessive gap which must be left between the two helices of double helical gears to facilitate grinding. Such a gap is, of course, unnecessary with the shaved and nitrided gear technique introduced since these particular gears were designed. The annulus pitch circle diameter is 14 in. and the reduction in speed is from 6000 to 1500 giving a ratio of 4.0:1.

The English Electric Company of England have standardised on this form of gearing and a turbo-alternator from their range incorporating a 3250 hp. gear has recently been installed in the University of Alberta.

A further interesting example is to be found in the Allen 750 hp. Naval compound intercooled gas turbine driven alternator where two gears are used in series to give a reduction of 26,000/1800 r.p.m., i.e. a ratio of 19.5 : 1. The planet carrier provides the drive for the following pumps — cooling water, fuel, servo and lubricating oil. All this is achieved in a length of 24 in. and an outside diameter of 20 in. A gear of this type is shown in section in Fig. 7.

Steam Turbines: In most classes of ship, be they Naval or Merchant Marine, the demand for electrical power is rapidly increasing at a time when engine room spaces are being cut down. The advantages of saving in length given by the small sizes of epicyclic gears have been quickly appreciated and an increasing number of ship owners now regard their use as conventional, particularly for larger ratios.

The Canadian Pacific Railways ships *Empress of Britain* and *Empress of England* include turbo generators incorporating epicyclic gears to transmit 1600 hp. reducing 7000 to 600 r.p.m.

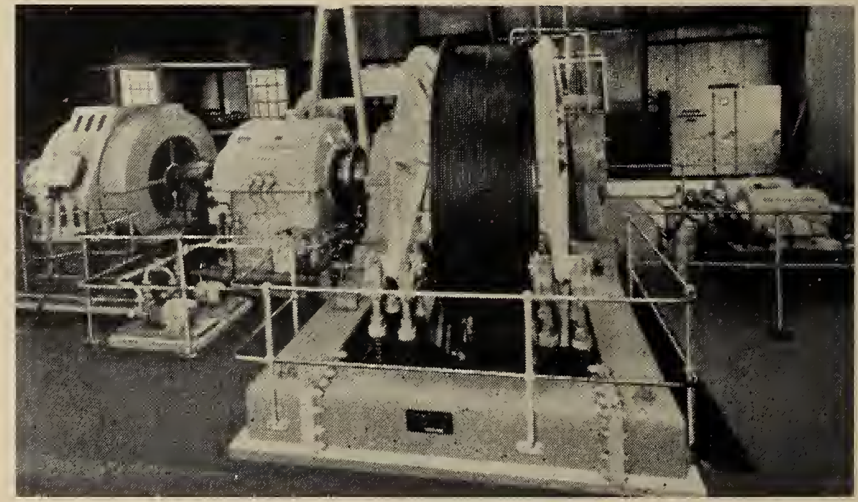
Fig. 8 shows a 450 hp. turbo-alternator for the Canada Steamship Lines *Fort Henry* which has been in service for five years. The gear has an annulus diameter of only 9 in., speeds 9000/1800 r.p.m. On one occasion this set was accidentally short-circuited. Inspection showed no damage to the gear except for a slight shoulder on the dowels which transmit the torque from the planet carrier to the low speed shaft. In installations where a short-circuit test is specified as part of the acceptance trials, loads of up to twelve times full load torque may be suffered by the gearing. In the authors' experience, the flexible system of the epicyclic gear stands up to these conditions better than parallel shaft gearing. In the latter, permanent damage has on occasion been observed.

The Steel Company of Wales are at present installing a high pressure/back pressure topping turbine manufactured by Richardson Westgarth (Hartlepool) Ltd. under licence from Brown Boveri & Co. Ltd. of Switzerland. The inlet steam conditions are 3000 p.s.i., 1050°F and the back pressure can vary from 620 to 670 p.s.i. The turbine runs at 9500 r.p.m. and the 9500 kw. alternator at 3000 r.p.m.

It will be appreciated that the steam conditions called for particular care in design. The turbine speed was chosen to keep down the mass of the turbine casing to minimise the effects of temperature gradient. Fig. 9 shows the neat solution to the gearing problem as photographed on the test bed. A star gear of 20 in. diameter was used to transmit 14,000 hp. One of the alternator bearings is housed in the gearbox and the rotating annulus of the gear is connected to the alternator shaft by the double tooth couplings which is an essential feature of the gear design.

From a very large variety of land installations, an interesting example is illustrated in Fig. 10 showing the arrangement of an Allen back pressure turbo alternator of 5000 h.p

Fig. 11. Mine Hoist Equipment incorporating Allen-Stoeckicht Epicyclic Gear.



reducing the turbine speed of 9500 r.p.m. to the alternator speeed of 1500 r.p.m.

General Industrial Transmissions: All the applications to which reference has so far been made have been for gearing driven either by steam or gas turbines. However, the use of epicyclic gearing is by no means confined to use with these particular prime movers. At the time of writing, the gear illustrated in Fig. 11 is the largest dimensioned Stoeckicht gear in service, although larger gears have been constructed and tested. It is capable of transmitting 3200 hp. with a reduction ratio from 486 to 64 r.p.m. i.e. a torque on the low speed shaft of over 260,000 lb.ft. The annulus diameter is 43 in. and the weight of the gear is 9 tons. It has been in service for four years on sinking duty at the Monktonhall Colliery of the U.K. National Coal Board. When the 3450 ft. shaft has been completed, the gear will be used for normal winding duty in a tower mounted motor driven friction hoist.

The small size and weight, compared with a parallel shaft gear, saved some $20,000 in the civil costs of the tower. Not only were the savings in weight and space advantageous but a further important consideration was that the inertia of the rotating parts of the epicyclic gear was only 687 lb.ft.sec.^{2} compared with 3478 lb.ft.sec.^{2} for a concentric parallel shaft gear for the same duty. This factor is particularly important in the acceleration, retardation and reversing of winding equipment and is by no means confined to this particular type of application. Special means were incorporated within the gear to enable it to operate as a temporary measure under conditions which could cause gross malalignment between the motor and winder drum. These conditions might occur during an excessive overwind on the adjacent winder mounted in the same tower.

A further illustration of the application of epicyclic gearing for low speed and high torque is given by the 160 hp. two-speed, triple reduction gear shown in Fig. 12. The maximum overall ratio of this gear is just over 80 : 1 and it is driven by a two-speed motor at 1500 or 750 r.p.m. These speeds, combined with the two-speed reduction of the gear, give output speeds of 24, 18, 12 or 9 r.p.m. At the lowest speed the output torque is 110,000 lb.ft. The high reduction and large torque are obtained from a gear which is only 6 ft. long and which weighs only 5½ tons. The diameter of the largest annulus is 30 in. The gear is to be installed in a new machine where space, weight and reliability are all equally important. This example illustrates the convenient way in which epicyclic gearing may be used for speed changing or reversing since the two-speed gear could easily be arranged to give opposite rotation.

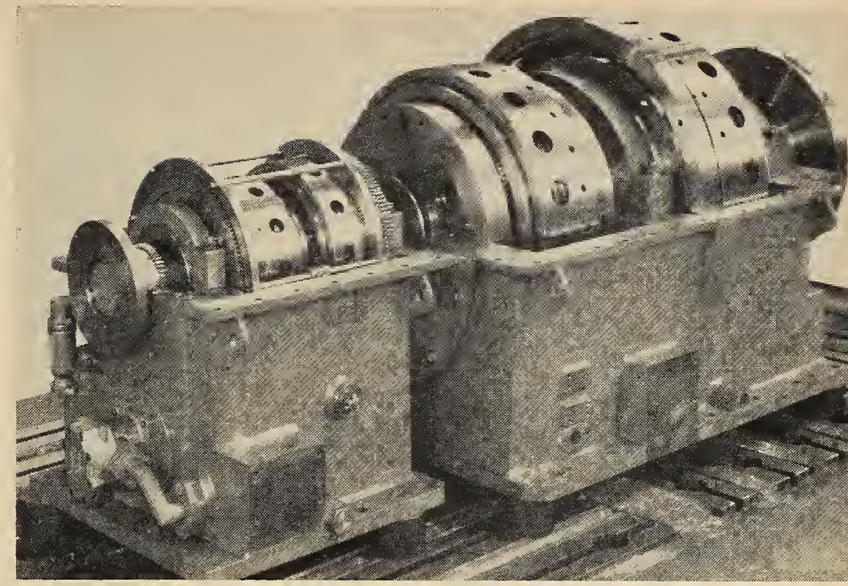


Fig. 12. Two Speed Triple Reduction Gear. Maximum Overall Ratio 80:1. Maximum Low Speed Torque 110,000 lb.ft. at 9 r.p.m.

Mention has already been made of the ease with which epicyclic gears may be used in installations where conditions are such that it may be desirable to de-clutch the prime mover from the driven member. Such gears are arranged so that the fixed member is held stationary by an hydraulic brake instead of being mechanically connected to the gear case. Release of the oil pressure in the brake de-clutches the gear. This operation may be carried out manually or arranged to work automatically due to an overspeed of the prime mover, e.g., an overspeeded turbine, or due to the application of excessive torque, e.g. a fouled propellor of a ship. Fig. 13 shows a submersible water turbine alternator manufactured by Escher Wyss and incorporating a B.H.S.-Stoeckicht speed increasing de-clutchable gear to transmit 1750 hp. from 165 to 1000 r.p.m. The gear has been in service for three years. It is arranged to de-clutch the alternator automatically in the event of a turbine overspeed. Such turbines are being increasingly used in Europe and de-clutchable gears of this type up to 7200 hp. have been made for them.

The National Aeronautical Establishment of Canada's wind tunnel at Ottawa, Ontario, will make use of an 11,000 hp. G.E.C. of England compressor. The 11,000 hp. synchronous motor runs at 1200 r.p.m. and drives the LP and HP compressors in tandem through epicyclic gearing as shown in Fig. 14. The speed increasing gear between the motor and LP compressor transmits the full horsepower and increases the motor speed from 1200 to 4500 r.p.m. It has an annulus diameter of only 27 in. The gear between the LP and HP compressors transmits 3600 hp. and increases the speed from 4500 to10,000 r.p.m. Its annulus diameter is 13 in. It will be noticed that both gears—of the star type—are housed in pedestals which contain the adjacent bearing for the motor and/or compressors. The only bearings in the gears are those for the star wheels. The gear tooth couplings which are incorporated in the gear eliminate the need for external flexible couplings. The use of epicyclic gears allowed each part of the installation to run at its best speed and at the same time maintained the desired in-line arrangement.

Reflections and Projections

The beginning of the last decade saw the introduction of Stoeckicht double helical gears and in this paper the authors have attempted to report on the successful application of these gears in a wide variety of installations. Progress has been most rapid in general industrial applications and in constant speed turbo drives. There is no indication that the limits of power, torque or speed are in sight and the authors believe that the new decade will see further development in all these respects.

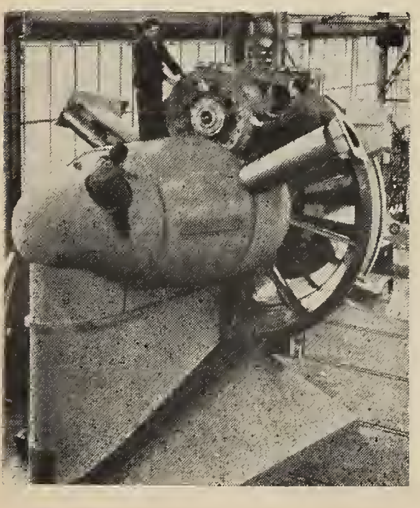
Possibly the next major progress can be expected in marine propulsion gearing. There are many ships operating at shaft horsepowers up to 10,000 which is well within established experience, whilst results obtained from such applications as mine hoist gears give confidence in meeting the type of loading to be expected in marine propulsion gearing.

The limited but important work already done in the marine propulsion field is, therefore, the note on which the authors would like to conclude this paper, with the same conviction that they showed eight years ago in predicting progress to date.

The experience so far with this type of gearing for main propulsion is largely confined to that obtained with Diesel engine ships of comparatively low power. The authors' own experience in this respect is limited, with one noteworthy exception, to gears for twin screw Seaward Defence Vessels in which reduction-reverse gearing to transmit 550 hp. giving a reduction ratio from 1000 to 625 r.p.m. ahead and 1000 to 500 r.p.m. astern has been extensively used.

H.M.S. *Brave Borderer*, a fast patrol boat designed and built by Vosper Ltd., of Portsmouth, England, and recently commissioned in the Royal Navy had a recorded speed of over 50 knots during her trials. The authors made use of epicyclic gearing not only to give a primary reduction between the Bristol-Siddeley Marine Proteus gas turbine and the flexible cardan shaft but also in the reduction-reversing gearbox which incorporates an hardened and ground E.N.V. spiral

Fig. 13. B.H.S.-Stoeckicht De-clutchable Speed Increasing Gear being erected in an Ascher Wyss Submersible Water Turbine-Alternator.



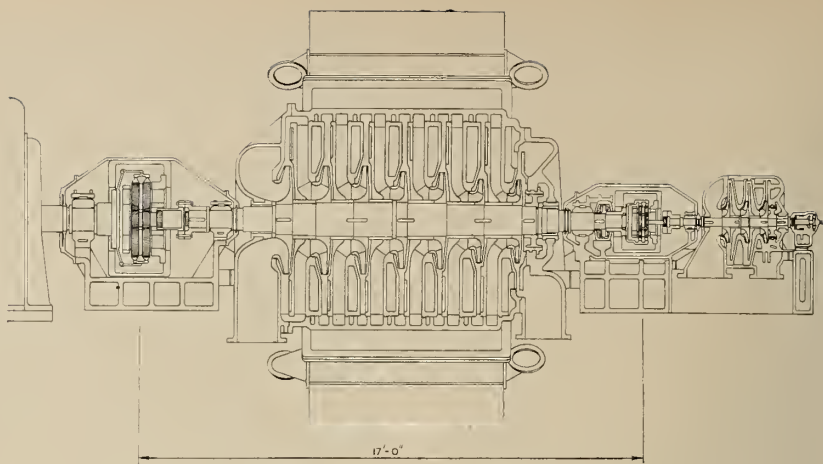


Fig. 14. 11,000 hp. Compressor incorporating Two Allen-Stoeckicht Speed Increasing Gears.

bevel vee drive. The maximum power transmitted is 3500 hp. and an idea of the size of the epicyclic gearing may be obtained from the fact that the annulus diameter is only 14 in. The total weight of the gear shown in Fig. 15, is less than two tons. In the author's opinion, the reduction-reversing epicyclic gearing could be most suitably applied in very much larger sizes to meet the requirements of many merchant vessels.

Other main propulsion gearing has already been built and tested and will shortly be in service at sea. Fig. 16 shows the Allen-Stoeckicht double reduction gearing to be fitted in M.V. *Bass Trader,* which will be in service this year as a cargo vehicle ferry between Australia and Tasmania. The gear, which meets Lloyds requirements, transmits 2200 hp. from a Deltic turbo-blown Diesel engine with a reduction ratio of 1630 to 180 r.p.m.

A description of the propulsion machinery for the new German Frigates has been given in The Marine Engineer and Naval Architect.[3] The only detailed information on the gear which has been released is as follows. For cruising, two speed de-clutchable epicyclic gears are used between the two 3000 hp. MAN Diesel engines and the propeller shaft. For full power, the second of the two available speeds from the two speed gearbox is used and in addition a large de-clutchable epicyclic gear transmits a further 13,000 hp. from a Brown Boveri gas turbine. Fig. 17 shows the gears following successful shore tests at B.H.S. Sonthofen.

In the future the authors consider that not only will epicyclic gears be used as straight reduction gears, multi-speed gears, reduction-reverse gears and de-clutchable gears, but in their opinion epicyclic gearing has a part to play in combination with very large parallel shaft gears. Increasing speeds of prime movers and increasing powers required — for example, by very large tankers – make the gear problem such that possibly the limit is being reached with parallel shaft gearing and, already, hardened gears are being considered. In this connection, epicyclic gearing can probably play a most useful part to give in a very compact way the initial reduction in, say, applications where two turbines are combined through a parallel shaft gear to drive one propeller shaft.

Finally, the authors would like to emphasise that they do not claim progress and development during the last ten years has taken place solely in epicyclic gearing. They do feel, however, that what has happened is not nearly so widely known as developments in parallel shaft gearing which have, of course, been taking place continually for a much longer period of time. In many spheres of engineering involving high powers it is not practicable for the prime mover and driven member to rotate at the same speed—from time to time engineers, both designers and users, are faced with transmission problems. If, on such occasions, this paper helps in some small way to stimulate thought and discussion on the possibilities of epicyclic gearing, compared with other types, then the authors will consider their efforts have been well worthwhile.

Acknowledgments

The authors wish to thank W. H. Allen Sons & Company Ltd. for permission to publish information given in the paper and for the facilities made available in the preparation of material. They are most grateful for the willing help of many of their colleagues without which the paper could not have been completed.

All the epicyclic gearing developments described are based on the principles of Dipl.-Ing. W. Stoeckicht, who kindly agreed to the paper being written.

Thanks are also due to Dipl.-Ing H. Barwig and to "Konstruktion", Springeh-Verlag, Berlin, for permission to use a translation of material taken from "Stoeckicht-Getriebe" by Dipl.-Ing. H. Barwig published in "Konstruktion" in 1954 and for the use of Fig. 1a and 1b. Mr. C. L. Deveson gave a great deal of help in the translation.

The authors are particularly grateful to Messrs. Ruston & Hornsby Ltd., Lincoln, England, for the early encouragement given by them in the standardisation of Allen-Stoeckicht epicyclic gears in their T.A. gas turbine. Fig. 6 was kindly supplied by them.

The Steel Company of Wales kindly agreed to Messrs. Richardson Westgarth (Hartlepool) Ltd. supplying information about their plant illustrated in Fig. 9.

B.H.S., Sonthofen, Germany, were kind enough to provide information and photographs for the applications illustrated in Fig. 13 and 17.

Fig. 14 and information about the installation of the compressor at Ottawa were kindly supplied by the General Electric Company of England.

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APPENDIX I

Types of Epicyclic Gears and Formulae for Ratios

Planetary Gear: In this type of gear the annulus is fixed to the casing and the planet carrier rotates in the same direction as the sunwheel. The sunwheel is connected to the high speed shaft and the planet carrier to the low speed shaft. This configuration is suitable for gear ratios between approximately 2.5 : 1 and 12 : 1.

The ratio is given by (A/S) + 1
Where
A = the number of teeth on the annulus.

S = the number of teeth on the sunwheel.

Star Gear: In this type of gear the planet carrier is fixed to the casing and the annulus rotates in the opposite direction to the sunwheel. The sunwheel is connected to the high speed shaft and the annulus to the low speed shaft. This configuration is suitable for gear ratios of between approximately 1.7 : 1 and 11 : 1.

The ratio is given by A/S.
Where
A = the number of teeth on the annulus.

S = the number of teeth on the sunwheel.

Solar Gear: In this type of gear the sunwheel is fixed to the casing and the annulus rotates in the same direction as the planet carrier. The annulus is connected to the high speed shaft and the planet carrier to the low speed shaft. This type is suitable for gear ratios between approximately 1.2 :1 and 1.7 : 1.

Solar gears are most generally used as one train in double reduction gears for special applications, of which the reverse reduction gear in Fig. 17 is an example.

The ratio is given by (S/A) + 1
Where
A = the number of teeth on the annulus.

S = the number of teeth on the sunwheel.

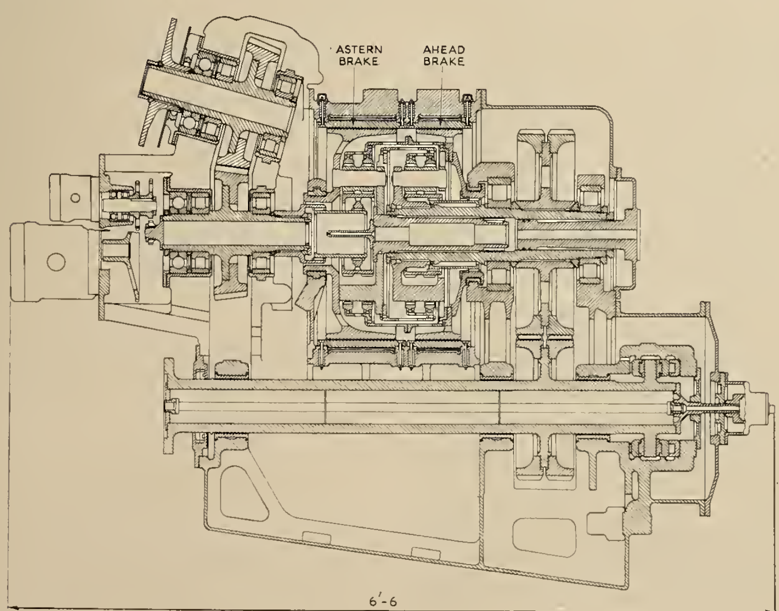
Any of the above types may be connected to achieve higher ratios than those obtainable in a single train.

APPENDIX II

The Nitriding Method of Case Hardening

Ordinary case hardening leads to troubles from distortion, from quenching cracks and from cracks developing during grinding operations. These sources of trouble are completely eliminated by the use of nitriding. In this process various alloy steels are used. The authors do not propose to discuss these except to say that they have experienced difficulties with nitriding steels containing aluminium, although these give the maximum hardness obtainable by this process (1,100 diamond point hardness, which is in excess of 65 Rockwell C). Further, these aluminium alloy steels have, after nitriding, a very brittle surface film which can easily lead to cracking and spalling, although this film may be removed by grinding or lapping before the parts are put into service. The authors noted with interest at the 1958 International Conference on Gearing held by the Institution of Mechanical Engineers in London,[4] that one European firm appears to be using such steels very successfully in gearing applications. The authors' experience is confined to nitriding steel not containing aluminium and giving a hardness of 700 to 750 diamond point hardness, approxi-

Fig. 15. Sectional Arrangement of Allen-Stoeckicht Reduction-Reverse Gear for H.M.S. *Brave Borderer*.



mately 60 Rockwell C. With this steel they have experienced no difficulty with the surface film, and, in fact, carry out no post-nitriding processes on the teeth of the gears. The surface film is very thin and soft and is not harmful in any way. In fact, it may aid running-in.

The hardness achieved by nitriding comes from heating the components for some 40 to 90 hr. in an atmosphere of ammonia gas at a temperature of about 500°C. The gas dissociates and some of the atomic nitrogen which is formed diffuses into the steel to form alloy nitrides. These are stable and give rise to a hard case without the need for further treatment. During the process the parts increase in size slightly to the extent of some .0005 in. per side, but this expansion is quite uniform so that due allowance can be made for it in machining. By reason of the growth freedom from distortion cannot be absolute, but for practical purposes it can be taken as being so.

The gradual diminution of hardness of the case as it merges into the core is considered by the authors to be most advantageous for hardened gear wheels. It is generally recognized that the fatigue resistance of steel is materially enhanced by nitriding. Its effect is to increase the strength of the surface layer and leave this layer in a state of compression. Again, this is advantageous in considering the alternating stresses which take place in gear teeth. A further advantage of nitriding steel is that it retains a very high degree of hardness up to the temperature at which the process is originally carried out. It will be appreciated, therefore, that any overheating caused by a temporary lack of lubrication is much less likely to result in seizing or scuffing than would be the case with ordinary case-hardened materials.

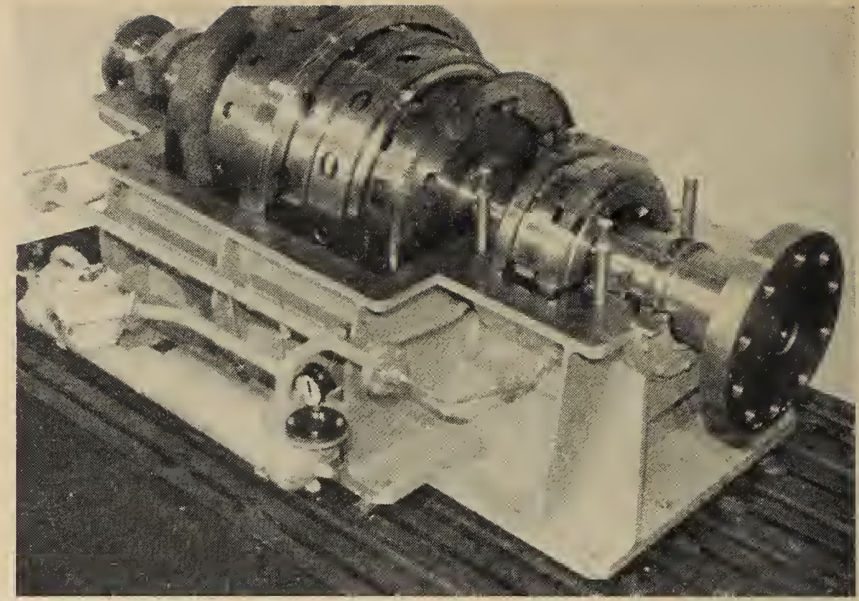
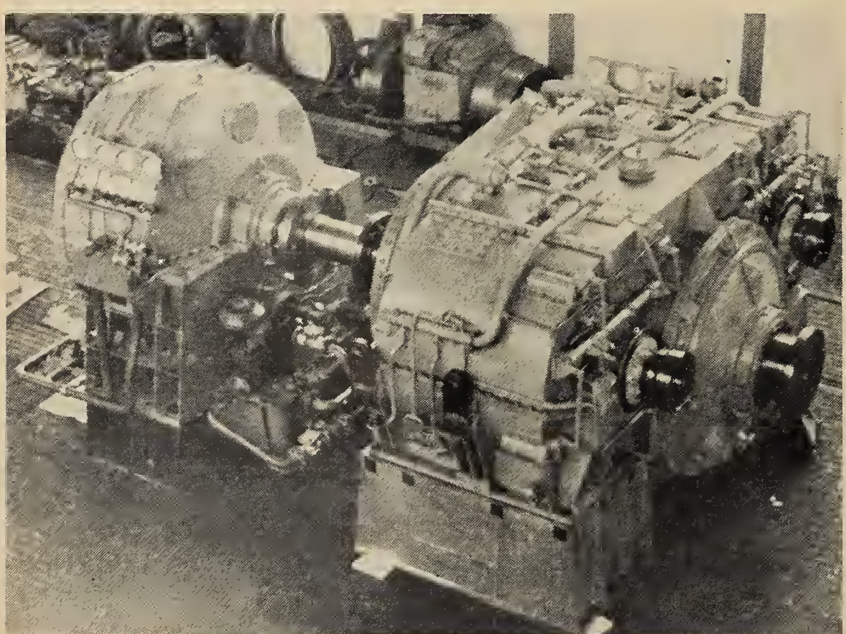


Fig. 16. Main propulsion gears transmitting 2200 hp. from 1630 to 180 r.p.m. Deltic engines Tasmanian Ferry of Australian National Line.

The components to be nitrided are machined in the hardened and tempered condition before nitriding, and the actual process is of a comparatively simple nature. The components are thoroughly cleaned to ensure removal of dirt and grease in a degreasing plant using Trichloroethylene. After this preparation the parts are placed in a box of special material which, in addition to being heat resisting, is also resistant to the action of ammonia gas. The components are packed in such a manner as to ensure free circulation of the ammonia gas throughout the charge, after which the cover is placed in position, a gas-tight seal being obtained by means of an asbestos and aluminium gasket. The sealed box is then enclosed in a suitable furnace which is maintained at a temperature between 500 and 510°C. The box containing the parts to be nitrided is fitted with inlet and outlet tubes for the ammonia gas which is circulated throughout the period of treatment. At regular intervals during this period a test is made on the exhaust gas in order to check the percentage of dissociation, the supply of ammonia gas being regulated according to the results of the test. The depth of the case depends on the period of nitriding; for most gear components the period is approximately 50 hr., but larger components may have this increased up to a maximum of approximately 90 hr. in order to achieve the greatest possible depth of case. When the period of nitriding has elapsed the box is withdrawn from the furnace and allowed to cool down, the circulation of ammonia gas being maintained until the temperature has fallen to about 80°C, when the cover is removed.

Any parts of the components which are not required to have a nitrided surface are protected by tinning prior to the nitriding treatment. The bores of planet wheels are polished by honing as a final operation.

Fig. 17. Combined Primary and Parallel Shaft Gear for Main Propulsion. B.H.S., Sonthofen.



MANAGEMENT—HORSE TRADING OR TRUSTEESHIP?

Lt. Col. L. F. Urwick,
Chairman of the Board, Urwick, Currie Limited, Toronto and Montreal

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

THE *Concise Oxford Dictionary* has a somewhat astonishing definition of the word *management*—

"**Management,** noun. In verbal senses; also, or especially, trickery, deceitful contrivance; **the Management,** governing body, board of directors."[1]

Of course, the *Concise Oxford Dictionary* was compiled by the late H. W. Fowler. And those who have enjoyed his *Modern English Usage* and his *The King's* (now, presumably, "the Queen's") *English* will be aware that he liked his little joke.[2] Possibly the association of boards of directors with 'deceitful contrivance' is just another of them.

But, if the investigation is pushed back a step further to Murray's full Oxford Dictionary, light begins to dawn.[3] The word management is derived from the French *manege*, a stable. In other words it has something to do with horses. Indeed in one local dialect use in Great Britain management still means manure. Now dealing in horses is traditionally a dishonest business. It is one in which the old adage *caveat emptor* still makes sense. If A tries to sell B a horse the popular assumptions are simple. They run like this:

i. If it was really a good horse A wouldn't want to sell it.

ii. Therefore there is probably something wrong with the horse.

iii. In consequence—

a. A's description of the horse is presumably false.

b. The price he is asking for the horse is certainly greater than its value.

c. While he may produce a veterinary certificate there are all kinds of possible snags which a cursory veterinary examination can't unearth, a vicious temperament or a preference for going through obstacles instead of over them.

iv. The deal therefore reduces itself to a battle of wits. B pits his knowledge of horses against A's anxiety to get rid of that particular animal. And if B is 'had for a mug' he more or less blames himself.

One of the difficulties of discussing management is that many people don't seem to have made up their minds whether *all* business behaviour is, or should be, on this horse-trading basis or not.

Arthur Bryant in his *English Saga* has a brilliant description of the small employers of the early industrial revolution—

"Though men often of splendid vigour, courage and independence, they were without the ruling tradition of responsibility and *noblesse oblige,* and the professors of economic science told them that such scruples were in any case antiquated and useless. They had one main concern, to get rich, and by every legitimate method available. As is often the way with servants turned master, they tended to confuse discipline with terror. Their own manners were rough and brutal, and they saw no reason to soften them in their relations with employees."[4]

That is from a chapter headed Dark Satanic Mills. In it he refers later to "the dual nature of early nineteenth century Britain and the legacy of discontent and social division we still inherit from its tragic dualism."[5]

It may well be argued 'All that's far away and long ago. It has nothing to do with us today. Ideas have changed.' But this is not so certain. There is current writing which is not so far removed from "the professors of economic science" to whom Bryant refers. One author, on the staff of *The Economist*, has argued:—

"It is noticeable that all discussions on the nature of management . . . consistently play down its *business* side—its money-making function. . . . The professional man is conservative and cautious by nature; the business man ought to (but now seldom does) think in terms of bold innovation—he must rush in wherever money can be made."[6]

Presumably that includes rushing into "betting, black-marketing, bucket-shops and brothels". The writer understands—he has no personal experience —that money can be made in these occupations in all countries.

Enterprise

Nor is the author quoted content to say that people who are interested in the art of managing are insufficiently interested in the financial side of business. He is quite clear that the economists' theories should come first and the actual behaviour of business people second. For instance, in a subsequent work he discusses the tendency for the entrepreneurial element in business to become specialized:— "The word 'enterprise' is often used to describe business, and quite often entirely falsely. Modern economists recognize this, and the Americans are even distinguishing 'entrepreneurial drones' among firms or business men. Such subtleties are all very well, but they leave the nature of the business man no longer entrepreneurial, and *hence play havoc with the neat rationalism of business behaviour, based solely on the profit motive, which is the starting point of almost all economic analysis.*"[7]

That is quite clear. 'The neat rationalism of business behaviour, based solely on the profit motive' which nineteenth century economists invented, must come first. Our job is to study, not how business people actually behave, still less how they should behave to be most effective. We must confine ourselves to seeing how far their actual behaviour squares with that theoretical stereotype.

It is 'beating the air' to discuss

management without clearing this central issue. The writer quoted is saying that the first requirement in every person who professes to be in business is that he should be 'on the make', personally and individually, as well as on behalf of the undertaking which employs him. That is "the neat rationalism of business behaviour, based solely on the profit motive", to which he refers.

That formula, in the actual conditions in which we live today, is not only misleading; it is dangerously misleading. It is perpetuating the "tragic dualism" to which Bryant refers. As a description of human behaviour it was admirably suited to the period in which it was evolved—the tail-end of a handicraft economy and the tentative beginnings of a machine economy. Then the one thing that mattered was that men should have the vigour and courage to make the transition, to pile up the much greater capital resources which a machine economy required. If the only way to do that was an all-out reliance on personal greed, if the only way to persuade the mass of the population to face the change was to threaten the individual with starvation if he was unadaptable, then perhaps the professors of economic science were right for their period.

For today they are utterly and tragically wrong. A number of things have occurred in the last century and a half.

a. Broadly speaking, the capital has been found. While the world is still in the middle of a technological revolution, the great mass of the people engaged in business are in comparatively large organizations. In any event they are wage and salary-earning employees. It is useless to talk to them about the *profit motive*. They do not participate in profit directly. And if there is one thing for which no-one in the world feels any interest and enthusiasm, it is that someone else should enjoy a larger income than he does. To quote Peter Drucker, whose *The Practice of Management*[8] is the best book on the subject which has come out of the U.S.A. in the last decade,

"It is irrelevant for an understanding of business behaviour, including an understanding of profit and profitability, whether there is a profit motive or not. That Jim Smith is in business to make a profit concerns only him and the Recording Angel."[9]

b. Because men and women do work in large organizations they have quite inevitably organized to protect their common interests as producers or as workers in the distribution trades. They are also consumers. But in this capacity they are what has been described as " a disordered dust of individuals". They have no daily contact to enforce association.

c. Owners and managers on the other hand are compelled by the logic of a free economy to give first attention to the interests of consumers. While Jim Smith or a group of anonymous stockholders may be in business to make a profit, they can only do so on one condition, that they supply at a price which consumers are prepared to pay, goods and services which consumers need. To quote Drucker again, "there is only one valid definition of business purpose, *to create a customer*."[10]

d. It is therefore not surprising that there has been a certain amount of friction between organized workers, concentrated on their interests as producers, and owners and managers, who are trustees, willy-nilly, for the interests of consumers. This friction is no-one's fault. To ascribe it to "blood-sucking capitalists" or to "irresponsible trade union agitators" is a piece of primitive animism. It is on a par with thinking that disease is caused by the wrath of some god or other or with making a wax doll, representing your 'enemy', and sticking pins into it accompanied by the prescribed imprecations.

e. There is only one way out of this impasse, for owners and managers to reassert the leadership of the people working in business undertakings which, owing to circumstances, has been assumed by others. Today, the very phrase "the men's leaders" means trade union officials, not the owners and managers, the officers, of the organizations in which they work.

f. To do this they must clear away one more handicap imposed by false economic thinking, the idea that the relations between the employee and the employing agency are exclusively an individual contract. That is another of the bulwarks of individualist *laissez faire* economics which circumstance has washed away. We talk as though it were still there—of the law of master and servant, for instance. But the mere fact that men and women are associated in business undertakings means that such undertakings are systems of *social* co-operation. It is not suggested that managers should fail to consider and to understand each individual working with them. Of course they must do so. But, beyond and additional to this, they should cultivate understanding of the social sentiments of the groups for which they are responsible.

This is the most serious handicap that the persistence of economic theory which no longer corresponds with the facts has laid upon the free societies. Many people still insist on talking and acting as if they had only to deal with a series of individuals and their motives, each considered as an individual. And it is often argued that these individual motives are what make men tick—the predominant issue. Nothing could be further from the truth. It is fatally easy to be cynical about this, to say that 'every man has his price', 'all that the worker cares about is what's in the pay packet at the end of the week', and so on. The answer to the first fallacy is a question—'What is *your* price, my friend?' The answer to the second is equally simple. If all the worker cares about is his personal gain, why is industry troubled with persistent restriction of output, both conscious and unconscious? The fact is that the vast majority of human beings care far more for social approval, and are more deterred by fear of social disapproval than by any individual reward or penalty. There are a small minority in most populations who really are indifferent to social disapproval; an appreciable percentage of them are in prison.

Six Points

These are six points which every manager should keep in mind:—

1. Except for those who start businesses or who are shareholders, there is no such thing as the profit motive;
2. Men and women who work in close association will organize inevitably to protect their common interests as producers;
3. In a free and competitive economy owners and managers must act as trustees for the interests of consumers. To supply goods or services which the community needs is the purpose of business;
4. There is bound to be some conflict between representatives of the wage-earning group protecting their producer-interests and the managers. But there is no need to personalize this conflict. It is merely a demarcation dispute;
5. It will disappear if owners and managers will recognize that they have a duty to *lead* those they manage;
6. They should make a start in this task by realizing that they are concerned not only with the right relations with each individual employed, but with the social sentiments of the whole group with whom they have to work. They should not neglect the individual. They must attend to both.

If it is the duty of every manager to lead the members of the group for which he is responsible, what is leadership? Chester Barnard has said "leadership has been the subject of an extraordinary amount of dogmatically-stated nonsense".[11] As soon as the word is mentioned men's minds jump to a Napoleon or a Churchill, just as they find it difficult to use the word poetry without thinking of Shakespeare, or music without thinking of Bach or Beethoven. But that is misleading. The world is full of poetry and music: these things are not only the privilege of giants.

It is so with leadership. Properly understood it is near to a universal activity; almost everyone leads in something. It is particularly important in business today for the reasons I have given. The task facing owners and managers is to change men's minds, to persuade them to abandon the sour, cynical attitude to business which circumstances reinforced by the persistence of *laissez-faire* individualist economics in circumstances to which it was no longer applicable, have stamped on their consciousness.

Business is a social activity: every business is a system of human co-operation. And men cannot co-operate together effectively *in action* without leadership. They can decide *what* they want to do by talking about it. But when it comes to doing it, they must have a leader. The reason is simple. Without a leader they cannot keep time; their efforts become dis-synchronized and therefore ineffective. An orchestra needs a conductor. That is why there are positions of authority in business. Men can't see the conductor all the time. He has to communicate with them. And they need to know that each communication is authentic. It comes from a position which is entitled to communicate with them on that subject.[12] That is what a position of authority, any manager's position, is—a clearing-house in a system of communication.

Authority, however, depends for its effect on the recipient. If he refuses to act on a communication, its authority is gone as far as he is concerned.[13] The formal organization—the kind of thing shown on an organization chart—is never, by itself, enough. It is formal, impersonal. If men are to breathe life into it, it has to be supplemented by leadership. Leadership is really a very simple idea. It is a kind of behaviour, the kind of behaviour on the part of an individual in a position of authority which inclines others to accept his guidance. It is a catalyst. It transforms authority—"the formal right to require action of others" into power —"the ability to make things happen". Those definitions are from Mary Parker Follett.[14] Everyone in a position of authority exercises leadership. The problem is whether it is effective or ineffective. Every subaltern officer, every manager has to be a leader: the only question is 'how good or how bad a leader?'

What does a leader do? Broadly, four things:—

i. He *represents* the purpose of the system of co-operation, the group, both to those inside it and to the outside world. Men cannot co-operate together effectively unless they are agreed as to the purpose for which they are co-operating. He is the personal embodiment of the common purpose.

ii. He *initiates* or causes to be initiated the changes which are necessary to keep the group effort in line with that common purpose. No group, by itself, precipitates change except very slowly. It always prefers its current social pattern, its way of life.

iii. He *administers* the group. He keeps its routines tidy and economical. There is an old Latin motto *Ubi ordo deficit, nulla virtus sufficit*. It may be translated freely "No high quality avails, where the rule of order fails". No business can function without routines.

iv. That means that much of a leader's time must be preempted in his fourth duty—*interpretation*. He has to be perpetually explaining to those associated with him the *reasons* for things.[15]

In short the manager as a leader has a good many other things to do besides managing. Managing, administration, in the strict sense, is only a quarter of his job. That is not surprising. Competitive business is a form of warfare. And no less an authority than Napoleon once observed that "in war, the moral is to the material as three is to one".[16] What qualities does a leader need? Field Marshal Sir William Slim—Bill Slim who made the 14th, "the forgotten army", into an army which those who fought with it will never forget—says five:—

Courage because it is the basis of all virtues in man and beast. But the higher you are in an organization, the more must your courage be moral courage.

Will-Power because it is extraordinary the amount of opposition you will meet when you want to do anything. This will come especially from your own staff who will be convinced that they are protecting your best interests. You have to get over that one.

Flexibility of Mind because we live in a changing world and without flexibility of mind strength of will may become a danger.

Knowledge, not of how to do the other fellow's job, but enough to appreciate the difficulties subordinates will meet, the time it will take them to do things and the sort of help they will want.

If he has these four qualities, he continued, a man will be a leader. But he will only be a leader for good if he adds a fifth. "The last quality on which all the other qualities have to be based, is:—*Integrity*—the thing that makes people trust you."[17]

Emphasis on Integrity

It is interesting to note that a man as different from Slim in experience and outlook as Peter Drucker places the same emphasis on Integrity. In his book, already quoted, he mentions the word no less than 20 times as *the* quality essential in a manager. For instance, "the best practices will fail to breed the right spirit unless management bears witness for its own professed beliefs every time it appoints a man to a management job. The final proof of its sincerity and seriousness is uncompromising insistence on integrity of character."[13]

This is the reason why every manager has got to make a choice, a choice between the sour, cynical, traditional, horse-trading view of business already described, in which we assume that every man is out for his own advantage, and the modern, the management view, which regards the manager as a trustee for the interests of all concerned in the system of co-operation.

This latter view has been well described by Ralph Cordiner, Chairman of the General Electric Company:

"The General Electric Company is managed by professional managers. These managers, including myself, are not the owners of the business, but employees hired by the share owners through their elected directors to manage their business in the best balanced interests of all concerned . . . The work of managing is tending to become professional, as a distinct kind of work in itself. It is becoming a job that requires a great amount of thought, effort, and training in the principles as well as the techniques of management . . . . This professional approach requires, in fact, a dedication of the man's self and service not only to the owners of the business through his Board of Directors, but also as a steward to the Company's customers, its industry, its employees, and to the community at large. The professional manager must consciously place the balanced best interests of these ahead of his own personal interests. The corporate manager today thus has an opportunity and an obligation for service comparable to the highest traditions of any profession in the past."[19]

To be appointed a manager is to

fulfil Robert Louis Stevenson's epigram about matrimony; it is indeed "to domesticate the Recording Angel".[21]

A manager is in a fiduciary position, as Cordiner has emphasized. He is appointed by a corporation to assume some of the responsibility of ensuring that a group of persons, part of the system of co-operation, work unitedly and enthusiastically to realize the corporate purpose. If he puts himself and his interests first and the corporate purpose second, the members of that group will be the first people to know it. And they will react accordingly. They will rate him as lacking in integrity.

It may be, it frequently is, argued that this view of management as a trust undermines the whole philosophy of capitalism and makes nonsense of a free enterprise system. But to argue in this way is to fail to make a number of essential distinctions. These are:—

i. The difference between the profit of an institution and acquisitiveness of an individual;

ii. The difference between profit as a measuring device and profit as a purpose;

iii. The difference between profit as an insurance and profit as a purpose;

iv. The difference between starting a business and managing an established business;

v. The difference between managerial positions which call for entrepreneurial skill and those which do not;

vi. The difference between competition and co-operation.

Profit

Profit as a measure of the success of a business institution as a social entity is one thing: profit in the sense of an exceptionally high pecuniary reward to the individual working within such an institution is another. The first is a sign of well-being; the second is a symptom of weakness. As Drucker records, one of the most venerable and successful banks in the U.S.A. set its research department the problem of determining significant indices of whether the management of a corporation was good or bad. After investigating hundreds of companies the research team came up with one totally unexpected clue—"If the top executive in a company gets a salary several times as large as the salaries paid to Number Two, Three and Four men, you can be pretty sure that the firm is badly managed. But if the salary levels of the four or five men at the head of the ladder are all close together, then the performance and morale of the entire management group is likely to be high."[22]

From the standpoint adopted in this paper the result is not so totally unexpected. A man in a position of authority who uses the opportunity to 'feather his own nest' and to secure personal and pecuniary advantages conspicuously larger than those of his immediate colleagues will attract envy rather than loyalty. He will be lacking as a leader. But there could be no clearer piece of evidence than this opinion of a sober New York bank that institutional profit and personal pecuniary gain are in different categories. The latter is no measure of success as a manager.

Profit is an invaluable measuring device for measuring that a business undertaking is, in fact, fulfilling its social purpose by supplying consumers with goods or services which they need at the right prices. If an undertaking fails to do so it will cease to make a profit and, ultimately, go bankrupt. But a measuring device, a weighing-machine, for instance—we talk about a balance sheet—cannot be a purpose. Races are run against a stop-watch. But, the stop-watch is not the purpose of the race. It merely records the runners' performances.

Profit has other important social functions. It provides the new development and replacement capital without which business enterprises could not expand or, indeed, remain in being. But its functions, in this capacity, are analagous to those of insurance. And, once again, an insurance policy is not a purpose.

So long as it remains possible in any society for the individual to start up a business enterprise of any kind and, by producing or distributing goods or services more economically than his competitors to secure a share of the market, so long will that society have a free enterprise system. And so long will individuals who have enterpreneurial ability be stimulated by the large rewards resulting from success in such initiatives to instil a life-giving flow of new ideas and exceptional energy into its economic life. Such men are valuable to the society and merit both honour and high pecuniary rewards. But again, the competitive element in their conduct, while invaluable in starting new enterprises, is a passport to disaster when applied to a managerial position in an established business.

To be sure, the established enterprise needs entrepreneurial skills and initiative if it is to maintain its place in the market. But it needs these skills in only a proportion, and that not usually a large proportion, of its managerial personnel. In common with almost all the other functions of business, entrepreneurial skill has become increasingly specialized during the present century. Its locus in any established business tends to be primarily with those concerned with merchandising, selling and the design of new products in engineering and research departments.

The great majority of managers in an established business are concerned particularly with organizing collaboration not competition. And even those whose functions are predominantly entrepreneurial have to remember continuously that they are units in an *organized* system of co-operation. Personal conduct which is geared too manifestly to the furtherance of individual ideas and, still more, to the attainment of personal advantage, whether social or pecuniary, is bound to put them at odds with their colleagues and to weaken the solidarity and team-spirit of the group. Indeed, one of the most difficult problems facing the chief executive, the principal manager, in any large modern business undertaking is to reconcile his initiators, the men who are fertile in new ideas, the men with the entrepreneurial outlook, with his faithful administrators, the men who keep the established routines of the undertaking running smoothly, day in and day out, year in and year out.[23]

Profit Motive

In sum the so-called profit motive and the competition between business undertakings which are characteristic of a free economy have important limitations. If they are applied to the conduct of individuals within an established undertaking:—

a. the profit motive is ineffective with those who do not participate directly in ownership and may, in the form of conspicuously high salaries or special bonuses to those who are supposed by ownership to contribute particularly to profitability, be translated by associates and subordinates into an expression of the corruption of power, which undermines rather than reinforces authority;

b. Individual competitiveness is not only directly deleterious to co-operation. The belief among subordinates that it is a principal concern of a superior or superiors will issue in a cynical and sceptical attitude which will render it impossible to generate a high morale in any group so affected.

These considerations are merely a restatement from a particular angle of the general principle stated earlier in this paper that the manager must be concerned with the social sentiments of the group responsible to him as well as with their individual reactions. Profit and competitiveness are both stimuli which operate on the individual. From the standpoint of group feeling and morale they have different effects. A good profit showing may have a positive effect on a group which does not participate directly in the financial rewards involved, merely as evidence that they have done a useful job collectively. But, after over a century of socialist propaganda, to place too much reliance on this as a factor in stimulating morale is optimistic. The reverse argument that ownership is appropriating an illegitimate proportion of the results of the co-operative effort is too easy to advance and too difficult to answer convincingly. Individual competitiveness always undermines co-operation. Group sentiment is almost invariably hostile to those who seem to be exceptionally endowed: the individuals sufficiently generous-minded to welcome the accelerated promotion of others are a small minority.[24]

Hitherto the free societies have failed to distinguish clearly between the different functions of profit. They have used the blanket phrase, the profit motive, without sufficient analysis of who is motivated and how to do what. Similarly they have talked glibly about competition without distinguishing competition between business undertakings from competition between individuals employed by the same undertaking who are supposed to be co-operating. Consequently there has been no sufficient analysis of the differences in ethical attitude appropriate in an entrepreneur and in the salaried manager in an established undertaking. Relying on an outworn economic theory long after the objective circumstances which justified it had passed, free enterprise has been brought into question among large elements of the population in most of the industrialized countries.

Owing to confusion between corporate objectives and individual ambitions, too many managers have talked as though business existed for the few, the privileged. In consequence they have lost the support and interest of the many. Because they have been hard-boiled, or, as many would say, realistic, about the right of those with the power of ownership to be as tough as they please with those who have not that power, they have brought ownership itself into disrepute. Again, Drucker has the pertinent phrase, "capitalism is being attacked not because it is inefficient or misgoverned, but because it is cynical."[25] That is a position which, if it is allowed to continue in a political democracy can have only one end—the expropriation of the property-owning and managerial classes.

If that position is to be corrected two things are essential:—

1. A *common purpose* for all those who co-operate in economic undertakings. To supply goods and services which the community needs effectively and economically is capable of being elevated into such a common purpose. Realizing a larger profit for a group of anonymous stockholders is not.

2. Constructive and ethically defensible *leadership* in pursuit of that common purpose by all those in a position of responsibility in economic life. A manager has only two means open to him of convincing those under his authority that he is a leader and not merely a person in a position of authority. These are:—

a. absolute integrity in pursuit of the common purpose;

b. within the limits imposed by that purpose, a real concern for the well-being and development of each individual responsible to him and for the social sentiments of the group.

He can only approach these tasks if he is clear that he is a trustee for the interests of all concerned in the system of co-operation and not merely a horse-trader. In other words, "the tradition of responsibility and *noblesse oblige*" which the professors of economic science rejected has become, once again, 'the headstone in the corner'.

Conclusion

For generations the cynic's answer to this challenge to leadership has been "I'm not in business for my health". That is perhaps the silliest phrase that has ever been invented to bolster an obsolete philosophy. The individual whose daily occupation is not good for his health is sickening for one of the occupational diseases of the rat race in early middle age. How come people call the big-shot row "ulcer gulch" instead of the old "front office"?[26] That may be his affair, as an individual. But as a citizen, a member of a community, he has some responsibility for the health of his society. The majority of the citizens of the modern industrial nations are engaged in business. If men and women are not in business for their health our hopes of social progress are an illusion. To quote Drucker once more, "in a lasting society the public good must always rest on private virtue".[27]

The alternative creed has been stated succinctly by one of the most profound thinkers Great Britain has fathered in the last century, the late Professor Alfred North Whitehead, O.M.—"a great society is a society in which its men of business think greatly of their functions".[28]

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21. "You may think you have a conscience, but what is a conscience to a wife? . . . To marry is to domesticate the Recording Angel." R. L. Stevenson, **Virginibus Puerisque.**
22. Drucker, Op. Cit., pp. 174, 175.
23. For a fuller discussion of the problem of reconciling initiative and social stability in business vide the writer's "The Value of Eccentricity", **Harvard Business School Alumni Bulletin**, October 1959, pp. 6-17.
24. An example is the poor early academic showing and almost fantastic unpopularity at every stage of his career till he was 66 years of age, of the greatest man of the 20th century, Sir Winston Churchill. It has been recorded of him in 1940 "His life had scarcely brought him personal popularity on a wide scale till now. But there could be no mistaking what they felt about him as the cheers rang out; and then the hat came off in a wide sweep and a shy smile appeared. That, perhaps, was his reward after a long career in which he had so often stood alone." (Philip Guedalla, **Mr. Churchill**, London, Hodder and Stoughton, 1941, p. 310). Yet even Churchill's immense popularity and tremendous services in the second World War were no bulwark against the mounting dissatisfaction with laissez-faire economics which is the subject of this paper. In 1945 at the very hour of his triumph his party lost office, largely because the people of Great Britain mistrusted a capitalism which appeared to them untempered with a corresponding responsibility.
25. Drucker — Op. Cit., p. 392.
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27. Drucker — Op. Cit., p. 391.
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Discussion

THE POTENTIAL IN THE FREE-PISTON ENGINE PRINCIPLE

A. Braun,

Free Piston Development Company, Kingston.

The Engineering Journal, July, 1960, p. 57.

Author's reply

The idea of Mr. Martin Berlyn, with regard to the application of an aftercooled supercharger upstream or ahead of the compressor sections of free piston engines has quite recently been given considerable attention by several research and development groups. An excellent appraisal of its merits and shortcomings can be found in the ASME paper No. 55-A-147 by A. L. London. Mr. Berlyn's assumptions of the various r_v values are correct as well as his conclusion that the critical compressor discharge pressure can be raised by means of supercharging. The author did not stress this fact specifically but it was one of the points implied in the conclusion that in the FP field only the first steps have been undertaken and so many roads for its full exploration are still offering great promise.

Supercharging has been applied in recent designs and one of the main advantages is the reduction of weight and size per HP. In dealing with points like this one such important benefits as pointed out by Mr. Berlyn are often overlooked, whereas it has to be pointed out that a complication of the overall installation as well as higher SFC is the price one has to pay for these advantages. Therefore, as long as the initial pressure ratio is not reached, the designer should try to find ways that result in the same advantages and eliminate the complication of the whole power plant. Much development work can be eliminated in this process by suggestions such as Mr. Berlyn's which point out desirable engine characteristics which are seldom found in text books.

A lower r_v in the combustion chamber as pointed out in the discussion can in the case of FP engines be achieved, without sacrifice, by other means and moreover with higher ignition temperatures at the same ignition pressure. Another most important characteristic, namely starting, improves considerably under these conditions. Once the critical pressure ratio will be reached it remains a question whether or not to intercool between supercharger and compressor or even compressor and combustion cylinder but this question might better be answered at such time.

Mr. R. G. Fuller has been associated with FP engines for a considerable number of years and has during this time had the opportunity to follow closely the performance of numerous installations under many different conditions and his remarks in this regard should accordingly be given careful consideration. An interesting point in his discussion is the comparison of FP and Open Cycle or G.T. marine installations particularly since in this field some of the advantages that the FP engine offers have not even been utilized as yet, such as after-burning for above rated load conditions etc.

Referring to Fig. 1 in Mr. Fuller's discussion it should be emphasized again that the temperatures quoted are maximum **cycle** temperatures which occur only intermittently in a FP engine, whereas they would be continuous in the combustion chamber and turbine entry of the gas turbine. The gas turbine is therefore again depending much more on high grade and expensive materials than any reciprocating engine (see Fig. 4 of author's paper).

Another point that is most interesting is the insensitivity of FP engines to ambient conditions and the difficulties in this regard that were experienced particularly with supercharged Diesel engines might well be remembered here.

In connection with marine FP turbines employing an astern wheel it comes to the author's mind that an often used argument against the application of FP engines to road vehicles is that the braking effort from the FP turbine would be so small, once the fuel lever is shut off, that extremely large brakes would be required. A relative simple solution to obtain an unusually high braking effect from this very turbine is to connect to the fuel lever a valve that opens at O-delivery and which diverts the gas from the forward nozzles to a reversed nozzle which blows on the back side of the turbine blading and which results in a similar situation as described by Mr. Fuller but on a turbine without astern wheel.

It can only be hoped that Mr. Fuller's suggestions with regard to Locomotive applications of FP engines will be given appropriate consideration in this country since the experiences in France and Russia in this field have been very successful (see paper by R. G. Fuller "The Free-Piston Gas Turbine" published by The Engineering Institute of Canada, June 1960).

As Mr. Cockshutt points out the air standard cycle approach of the author was taken to present the case of the FP engine on as simple a basis as possible and certainly in terms of actual engine behaviour caution is always required when applying any air standard cycle to study the effect of certain variables. It should be noted however that for related types of engines, such as reciprocating types, the conclusions out of such studies have also certainly their validity as apparent for example if one compares the average superiority of the diesel engine over the spark ignition engine, which is in this case primarily due to the higher possible compression ratio level in the diesel

(continued on page 122)

Automation and Control Engineering in Canada

Automatic Control of Machining Operations

PARTICULARLY in North America, great interest has been shown in the automation of operations involving machine tools. Perhaps the obvious field for application of automatic machining processes is that of high-speed mass-production of standard parts. Certainly control of such operations has been practised very successfully, but generally speaking the majority of machining work done by industry is on quite small lots of separate items. Automatic control is equally applicable to such short-run work, and can show considerable savings over conventional methods, provided it is applied with common sense.

Numerical Control

The term numerical control is used to indicate the use of numbers to describe a part that is to be made on a machine. The information represented by these numbers can then be fed on to a punched tape or other control medium, which is used to direct the operation of the machine.

Instead of the machine operator having to interpret a blueprint and convert dimensions into machine operations to achieve the desired result from the original workpiece, all data can be handled in advance by an engineer who converts dimensions, machine operating data, and tool information into numerical data that are transferred to the control medium. A reader on the machine converts the numerical data to instructions to the machine.

A part may be described numerically by using the conventional X, Y, Z co-ordinated together with mutual planes and angles. A corresponding system is used for machine axes.

Simple Operations

The simplest method of control is referred to as the positioning or point-to-point system. In this, the part and the tool are brought into the required relative positions in a controlled sequence. Thus, for example, to drill a series of holes in sheet metal a drill press can be provided with a table that is moveable in two directions by, say, feed screws and servo drives. The positions of the required holes can be referred to simply in terms of X and Y ordinates, and provided the workpiece reaches the correct position in the correct sequence it does not matter essentially whether it is moved first along the X or Y axis.

The control medium can also be used to start the drill when the workpiece is in position, and the positioning system can also be used to control vertical turret lathes, jig bores or similar more complicated machines.

Complex Operations

In the relatively simple positioning system it does not matter what path the workpiece or tool takes between each position. This path can, however, be controlled with great accuracy over its entire length, however complex the path may be. The system is known as a continuous path or contouring method and, as the name applies, can be applied to profiling or contouring operations.

The amount of data involved is much greater than in the simple positioning system, and may include reference to the three main axes and several angles and attitudes of tool and workpiece. With many continuous path systems a computer is used to handle the data; for example, to calculate the points around a circle. From these data, the dimensions and tolerances, the computer can provide necessary tool data and a tape that will control production of the circle to the required limits.

Control Data

The control medium to store data for either the positioning or contouring system may be punched cards or tape, or magnetic tape. Several commercial systems use 8-channel punched tape, but other numbers of channels and other media have their particular applications.

The simpler systems may use dimensions directly as control data, but the continuous path or contouring methods usually require binary coding. A check may be made on the machine by incorporation of a gauging system that continuously supplies data to correcting loops..

Applications

Numerical control has spread to almost all conventional machining operations both singly and in combination. Contour grinders can be controlled to finish such complex surfaces as turbine blades to dimensions of the order of several millionths of an inch.

Control has also extended beyond machining work into such fields as joining by riveting or welding, assembly of small components, and tube-bending.

Economic Advantages

The use of numerical control has obvious advantages in relieving the operating staff from the responsibility of interpreting written or diagramatic data into practical results, and in avoiding human fatigue or error with greater possibilty of increased accuracy in the final product. The main attraction of such a control system, however, is most likely an economic one.

Expensive machine tools give returns only when they are producing, and the working time of machines in a 'conventional' shop is often an alarmingly low proportion of the overall work-period. It has been shown in practice that machine tools that have been adapted for use with numerical control can be in productive use three to five times more than under a conventional set-up.

One big advantage of numerical control is that it can eliminate jigs, templates, holding fixtures, and other expensive tools that take a lot of time to prepare. For example, in the manufacture of a honeycomb die cavity, a comparison has been given of 122 hours lead time by numerical control compared with 550 hours by conventional methods. By numerical control, the initial stages of planning, calculating, and tape preparation occupy 68 hours, compared with 28 hours planning and calculating conventionally (no tape preparation required). From then on, however, the conventional method requires 482 hours for seven operations that are eliminated by numerical control: loft drawing, station master template, plaster mould template, rigging template and fairing, plaster splash, male casting from plaster splash, and casting metal die. From this point the conventional method ends with 60 hours to finish grinding of the die, whereas the numerical control system proceeds directly from its prepared tape to machine the die (24 hours) and finish grind it (30 hours).

This great reduction in lead time indicates some of the fields that are promising for application of numerical control, and emphasises that it is not only the long-run mass-produced work that can benefit. Reduction of lead time may be one of the main reasons for applying numerical control. Others include: large numbers of machine operations or set-ups; complicated machining operations; short machining time but long set-up time; short runs and multiple variations in a complex part; to reduce human error, particularly with very complicated operations; to produce more or less to order parts that are normally so involved that it is uneconomical to provide a sufficiently large stock of them as spares.

Examples of Controls

An idea of the scope of automatic control systems for machine operations can be gained from the general outline given so far. As in most cases of automatic control applications, it is possible to automate almost any required work, but how much can be achieved in practice depends on how much the operator can afford to pay, in relation to the advantages that might be obtained.

Relatively simple control systems may cost something of the order of \$3000 to \$9000; continuous path systems and other special installations may run to ten times these figures or even considerably more for special-purpose systems.

At the lower end of the scale, one example is the case of conversion of a standard capstan lathe to automatic operation by a stepping relay control system. Control includes a stepping relay and a patchcord programming panel, of which the interconnections are set to control certain functions of the lathe; for example, open and close chuck jaws, feed-in bar, change spindle speed and turret head position, adjust cross-slide and capstan slide feed rates. The conversion involved no major alteration beyond addition of actuating mechanisms, including air cylinders, hydraulic check cylinders, and necessary drives.

A much more sophisticated specially-designed machine that has recently been described is a turret lathe that starts as a manually-operated machine and can be developed by addition of control blocks until it can perform very complex operations by numerical control. The basic machine is equipped with the necessary servo-feeds, and even manual operation is controlled through servo links. Numerical control blocks can be added to provide positioning control and contour control of the machine's two turrets. The contour or continuous path control receives pre-calculated data recorded on a punched tape. Positioning control data are stored in a 10,000-bit magnetic core memory, in which the instructions are recorded during an initial manual machining operation. It is proposed to provide the means of reading instructions into the magnetic core matrix from another punched tape prepared in advance of the machining operation.

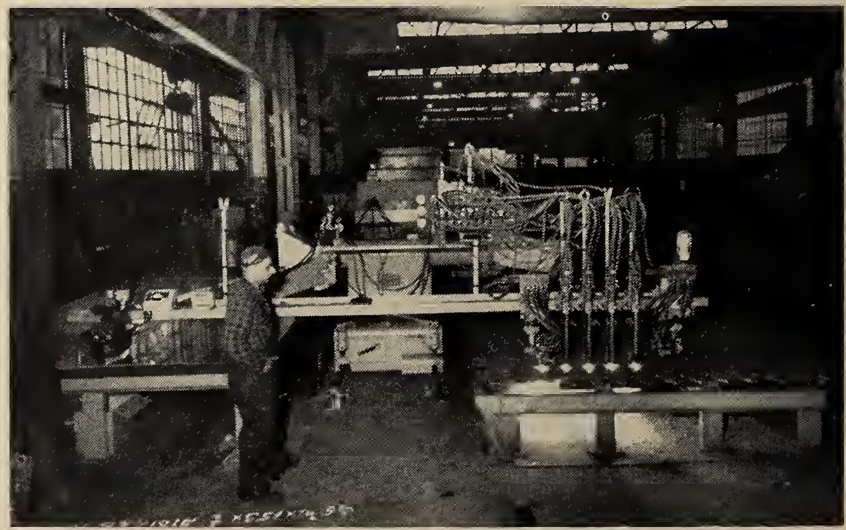
Automatic Inspection

With proper attention to all phases of an automatic program, great accuracy can be obtained; the system just mentioned is said to be accurate within 0.0005 in. However, inspection is still necessary and may become a problem when parts are being turned out at very high rates from an automatic system.

Various means of automatic inspection have been devised to help the job of the human inspector, who still has the final word on acceptance. One such system of automatic inspection is applied to a positioning system used in production of parts in large quantities, to accuracies of 0.001 in. The positioning system incorporates a servo-controlled table with movement along the X and Y axes. A punched tape is used to position selected inspection points at the tip of a stationary air probe sensing unit; any departures from correct size are indicated by extent and type, in thousandths of an inch, on a pneumatic gauge.

In the particular system mentioned here, vertical dimensions are checked by replacing the air probe with the arm of a mechanical dial indicator and manually checking thicknesses at at each of the stopping points on the tape-controlled inspection program. Such a system can obviously be developed further to permit inspection of more variables by automatic means.

The Travograph. By this ultra-modern method, an electronic "eye" guides four oxy-acetylene torches along the face of the material to follow a prepared design. Many intricate patterns can thus be cut, fast and with great accuracy—several thicknesses at one time, if required. *Photo courtesy Toronto Iron Works Limited*



Canadian Developments

New Use of Aluminum

Perfection of the extrusion process in the aluminum industry has made possible products as diverse as construction sections and aerosol containers. The construction sections, extruded with bulb corners, attain close to the full strength of steel and have only half its weight. They have been put to use extensively in modern power line towers, where they give an impression of giant bird wings.

The aerosol containers, on the other hand, are hand-size, compact objects. The lacework of the power towers contrasts sharply with their solid, seamless character. They have a bright, anodized surface.

Welding at high speed has also opened up a new terrain for aluminum. Pipe lines for oil fields, conveying oil, gas and water are being laid in the Western provinces, perhaps the longest of which is a 17-mile line in Alberta.

Another product of high-speed welding is the aluminum tank hopper car with a single hopper in the center, a design which has been unfeasible in the traditional rectangular hopper car.

The Methane Pioneer

Aluminum's ability to withstand extremely low temperatures has made it highly suitable for vessels carrying liquid gas. In 1959 the Methane Pioneer, a 3,000-ton tanker, was converted to carry 2,000 tons of liquid natural gas. Five aluminum cargo tanks insulated with balsa wood were installed in the ship to transport the liquid gas at a constant temperature of approximately -258° F. It was found that the aluminum could withstand both the low temperatures and variations in temperature from liquification and re-gasification. The ship departed from Texas and upon arrival in Great Britain had its cargo transferred to high storage tanks consisting of an aluminum container, insulation and an outer shell. An extruded aluminum pipe was used for the transfer.

Aluminum has found application in Arctic building for these same cold-resisting characteristics, as well as in Alpine snow fences. Shelters against avalanches have been built out of extruded aluminum tubing and formed sheet.

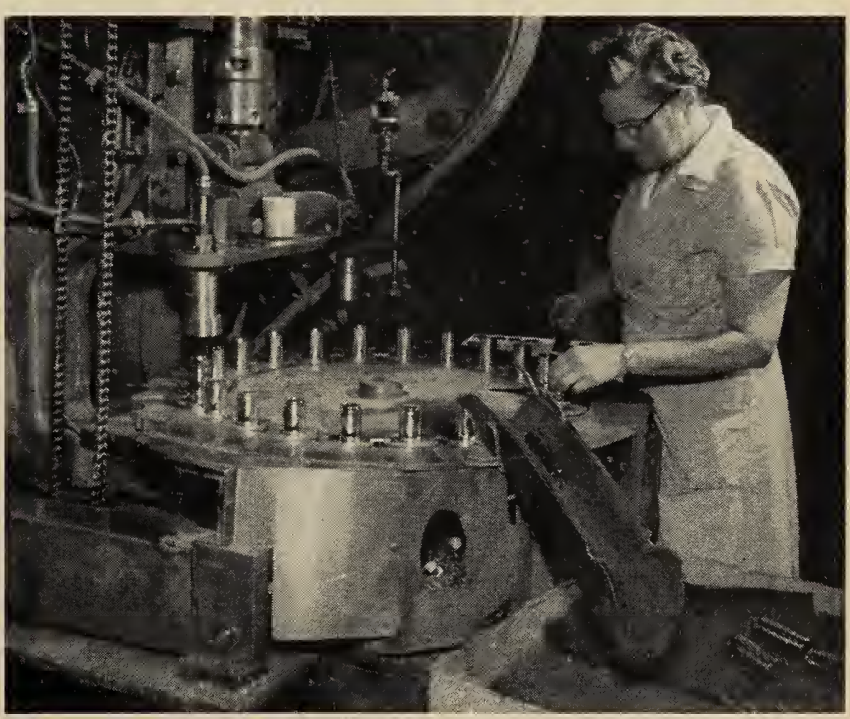
Effects of Anodizing

Anodizing has various effects upon aluminum, among them the acceleration of aluminum oxide formation. It gives a slightly milky appearance to the surface of most aluminum alloys, but in the case of silicon, gives a handsome dark grey tone to the alloy. The new Mackenzie building in Toronto is composed of grey anodized aluminum frames around modular panels of coloured glass, clear aluminum window sections and steel. Exposure to oxygen causes an oxide layer to form on the surface of these aluminum frames which, with anodizing, thickens and hardens giving protection to the metal.

The development of aluminum-magnesium alloys, as well as perfection of welding procedures, has produced an aluminum off-highway rock body for

trucks. In this vehicle the usual combination of steel with oak cushions is replaced by a single 1¼ in. aluminum plate, the aluminum absorbing the impact.

Preparation of impact extruded aluminum aerosol containers to take valve caps.



Uses of Copper

Generally speaking, copper and its alloys are not used for structural strength. Their appeal is in their design value, particularly their colour which ranges from pure copper to red brass, through architectural bronze to yellow brass, and to the white metal, nickel-silver.

Copper in building may appear in two general forms—as thin facing over steel sheet, tubes and structural shapes or as exterior curtain walls of bronze and other copper alloys. Bronze mullions and bronze-coloured Muntz metal spandrels have recently been used in combination to make a curtain wall. Bronze mullions give sharp edges which create a kind of shadow which lends a third dimension to a structure.

The Queen Elizabeth Hotel in Montreal drew heavily upon nickel-silver for ornamentation. Thirty-eight thousand pounds were used in door and window frames, stairway handrails, and the panels and ceiling in front of the main elevator doors.

Completed steelwork for TCA's 836 ft. x 175 ft. hangar at Montreal Airport. It is believed to be the longest cantilever roof in North America.

Radiant heating and air-conditioning

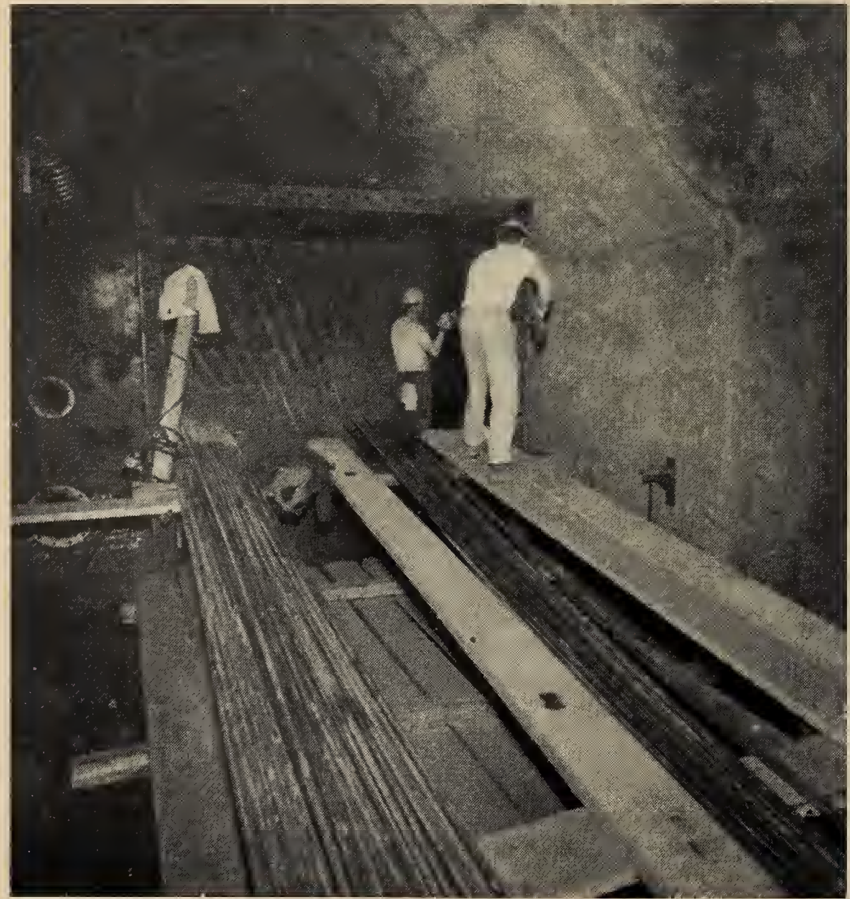
Copper is being used increasingly for radiant heating installations, where radiant panels decrease temperature variations in a room heated by convection currents from 10° F. to approximately ½° F. The Workmen's Compensation Hospital and Rehabilitation Centre in Toronto has such a system. Eight miles of copper tube were used in this building for hot and cold water lines as well as the radiant heating panels. The copper tube has virtually

no maintenance, low head loss due to friction and high resistance to corrosion.

Air-conditioning installations have also come to use copper more. Copper tubes are used in control and supply lines for test rigs as well as hydraulic and pneumatic control mechanisms. For control panel piping small-bore copper tube is used, and polyvinyl chloride clad tube where corrosion threatens.

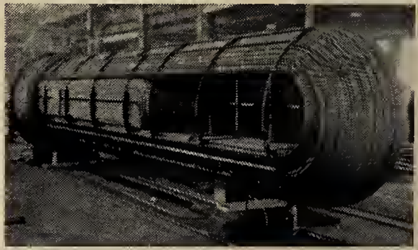
In hospitals and various medical facilities copper tube is used for carrying gases in surgery, therapy and resuscitation. Steam cleaned and capped until installation, oxygen tube draws from a central gas supply and runs into every room for use beside the patient's bed. In this way transport of heavy cylinders is eliminated and explosion hazards are reduced.

Installation of brass tubes in condensers, Richard L. Hearn Generating Station.



Generating Stations

While considering the uses of copper and copper alloys in the structural design of commercial buildings, it would be an error to overlook their use in electrical generating stations, since over 50% of the copper used in Canada is used in power-generating systems. The water-driven generating system of the St. Lawrence Seaway Power Project uses alone over 2,000,000 lb. of copper. Canada's largest steam-power station, the Richard L. Hearn Generating Station, uses vast quantities of cupro-nickel and



brass tubes for the feedwater heaters and condensers, not to speak of the generators.

One last application which is interesting to consider is sewage treatment plants. A copper-silicon alloy was specified for many parts of the Humber Sewage Treatment Plant — the weir plates, the guides for sluice gates, nuts, bolts and even the fixtures in the aeration tanks. It is copper's resistence to corrosion which makes it so valuable in this field.

International News

Uses of Stainless Steel

Stainless steel will sheath the $12 million United Engineering Building in New York City and many other modern metal and glass structures. It will take to the air in planes and in missiles. It will even line the nuclear reactors which may explode the limitations of conventional power sources.

The hardenable "Austenitic" stainless alloys are becoming ever more important to the aircraft industry. One of these alloys, for example, is the main constructional material in the B-70 Valkyrie chemical bomber, an aircraft which travels at speeds up to 2700 m.p.h. without damage from intense air friction heat. Semi-austenitic stainless steels resist corrosion exceptionally and can be hardened at temperatures low enough to minimize distortion and oxidation.

United Engineering Building

The problem of steel's high density has been met in the B-70 by a honeycomb sandwich structure. The stainless steel used in the Atlas ICBM airframe is of such a thin gauge that manufacturers refer to the missile as a stainless steel balloon. Resistance welding is possible on this hard-rolled type of stainless steel, whereas the heat treatable stainless steel used in the B-70 honeycombs calls for other welding methods.

Nuclear Reactor Applications

The development of a number of new stainless steel alloys has given rise to nuclear reactor applications. Low cobalt and boronated stainless are but two of these, the latter being an exceptionally good neutron absorber and thus a natural material for reactor shielding The combination of nitrogen, chromium, nickel and manganese in a fixed proportion gives an alloy which may be useful in many applications where there is a high temperature environment. It resists erosion, oxidation and corrosion at high temperatures and has a tensile strength in excess of 162,000 psi. at room temperature.

Slag washing of stainless steels has been developed to a point where the metal is applicable to fabrication of hot sections of jet aircraft, high temperature steam boilers and turbines, and nuclear reactors. Spinning, drawing, machining and polishing of slag-washed stainless is now possible.

Use in Instrumentation

Stainless steel foil can be made to a thickness of .0005 in. and it is thought that refinements are still ahead. Electronic tubes, missile and satellite instrumentation and honeycomb skin will all call increasingly upon this form of stainless steel. Foil 2 mils. thick, coated with radioactive tritinated titanium, has been used as an irradiation source in static eliminators and other instruments.

New Fabrication Techniques

Extrusion of stainless steels is an important development in that it will allow the fabrication of complex contours in stainless steel products. The extruded forms lend themselves to greater freedom of section design, their integral complex shapes replacing two or three traditional component parts. With extrusion, machining operations can be appreciably reduced and economy can be had in short run production when demand does not justify roll forming.

Roll forming has also been perfected as a stainless steel fabricating technique. Whereas earlier it was thought suitable only for mass production of standard sections, standard stainless steel shapes are now being produced at a relatively low cost on a job shop basis.

Fusion welding, because of the delicate technical applications to which stainless is put, must reach a high state of perfection. Severe standards are being met in the fusion of nuclear reactor components and the joining of stainless pressure vessels, chemical process piping and load-bearing aircraft parts.

Redstone Missile

Month to Month

Municipalities Urged to Speed up Planning of Winter Work's Program

The Chairman of the National Joint Committee on Wintertime Construction and Past-President of the Canadian Construction Association, Raymond Brunet, said recently that his committee had made a recommendation to the Federal Government that the scope of municipal projects eligible for assistance be increased. The committee also has asked that an earlier announcement be given than in the past so that municipal authorities have more time to prepare plans and specifications for the winter program.

Mr. Brunet pointed out that new regulations provide the municipalities with new incentives for wintertime work on municipal buildings other than schools and hospitals. He also said that engineering projects with subsidies for labour costs have been expanded to include above-ground sewage and water installations, as well as below-surface work, street lights and traffic signals.

"This program will of course not in itself solve the seasonal unemployment problem for the construction industry and there will be many municipalities who will be unable to participate, but it should provide very useful assistance to this end. Last winter the program expanded by roughly 50% over that of the initial program in the previous December-to-May period. This winter with the expanded scope of the scheme, more advance notice and more experience on the part of the municipalities, the program's usefulness should grow still more," said Mr. Brunet.

New American Institute for Certification Established

Establisment of an Institute for the Certification of Engineering Technicians and Technologists has been approved by the Board of Directors of the National Society of Professional Engineers, U.S.A.

The National Society will organize and operate the Institute to:

a. Determine by examination, endorsement, or otherwise, the qualifications of all persons who apply for certification.

b. Grant a certificate in the appropriate grade to applicants who successfully meet the criteria for certification.

The Institute, which is to be exclusively an examining body, will be operated by a board of directors comprising equal numbers of registered professional engineers and certified engineering technologists.

A. C. Friel, Midland, Michigan, chairman of the National Society's Committee on Engineering Technicians, told the group's Board of Directors that the establishment of the Institute "should provide a much needed means of recognizing the status of technician members of the technological team."

Friel pointed out that the Institute "should also lead to the upgrading of the education and work experience, as well as the continued self-development of the technician."

Advisory Committee at Essex College

The Advisory Committee to the Faculty of Applied Science at Essex College, Assumption University of Windsor is composed of practising professional engineers representing various branches of engineering and is a sub-committee of the Academic and Personnel Committee of the Board of Directors of Essex College.

It is basically the re-organization of the former Engineering Education Committee originally formed in October 1956 to recommend to the Board whether or not the university might establish a complete accredited program leading to the engineering degree in a minimum of four branches, namely, chemical, civil, electrical and mechanical engineering.

As a direct result of this recommendation, three degree courses were inaugurated at Essex College by the Board of Directors in 1957. This led to the establishment of the Faculty of Applied Science by the University Senate in the fall of 1959.

Registration for the 1959-60 term comprised 52 engineering students in the first year, 40 in the second and 26 in the third, for a total of 118 students. The first crop of graduates will receive their B.A.Sc. degree in the spring of 1961.

The Committee functions as an advisory group to the faculty, expressing the practical viewpoint of professional engineers on all phases of the applied science program. Among its immediate objectives are the placement of graduates in 1961, assistance to undergraduates in finding summer employment, and a continuing intensive public relations program.

As of May, based on a committee recommendation, a "placement package" consisting of pertinent information relative to the faculty and students was mailed to 319 industries and 60 consulting engineers mainly located in Southern Ontario and Western Quebec.

Mr. R. T. Waddington, Riverside, Ont., is chairman and Mr. D. D. Duquette, Windsor, Ont., is secretary.

E.I.C. Elections and Transfers

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective July 22, 1960.

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Member: G. E. Ellingham, F. E. Fernyhough, P. L. Money, W. A. Padgham, D. Sawatzky, R. Shklanka, K. H. C. Un.
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Junior to Member: D. G. Bishop, B. G. Brown, G. C. Burns, D. G. Delparte, W. A. Derry, R. N. Filson, J. A. J. Kavanagh, R. W. Kyle, S. E. Lawrence, M. F. Main, J. E. McGuire, D. G. Olafson, J. H. Peterson, A. Shklanka, G. R. Ursenbach, D. W. Wilson, J. E. Zuk.
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Student to Junior: L. P. Benoit, R. L. Blanchette, E. A. Cochrane.
Student: G. H. Morris.

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NEW BRUNSWICK

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MANITOBA

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President's Column

DURING the summer months, Presidential visits are being arranged to a number of important Canadian engineering organizations, such as the Department of Mines and Technical Surveys in Ottawa; National Research Laboratories, Ottawa; Ontario Research Foundation, Toronto; CARDE, Valcartier; etc. The purpose of these visits is to bring a closer liaison between these organizations and The Engineering Institute of Canada, because it is felt that the future development of Canadian engineering depends to quite a large extent on the fundamental work by these groups.

Courtesy visits were also made to the Ontario Association of Professional Engineers in Toronto and to the Corporation of Professional Engineers of Quebec.

The newly formed Executive Committee of Council met in Montreal on July 22nd for the first time, with the President, four Vice-Presidents, Treasurer, and several Councillors present. A considerable volume of Institute business was transacted and numerous reports of Committee and other groups were presented. The second meeting of the Executive Committee was held in St. Andrews, N.B. on September 9th.

At the bienniel Maritime Professional Engineers Meeting which was held in St. Andrews, N.B., September 7, 8 and 9th, your President was the guest speaker at one of the functions. An interesting program was arranged for this Maritime Meeting, which provided an excellent opportunity for the Engineering Institute Officers to meet the Maritime Engineers.

The various Committees of the Engineers Confederation Commission are energetically at work during these summer months, busily engaged with their respective assignments.

The Institute's delegates to the first Pan American Congress on Engineering Education being held in Buenos Aires, September 12th to September 18th, are Dean McLaughlin of Toronto and Dean Conn of Queen's.

The above Congress will be followed by the Sixth UPADI Congress, also at Buenos Aires, at which the Engineering Institute will be represented by a suitable delegation.

Encouraging responses are being obtained by the President in his communications with Vice-Presidents and Branch Chairmen regarding Branch activities being organized well in advance of the inauguration of fall programs. Now is the time to do the advance planning necessary to get interesting and attractive meetings for the coming season.

(Continued overleaf)

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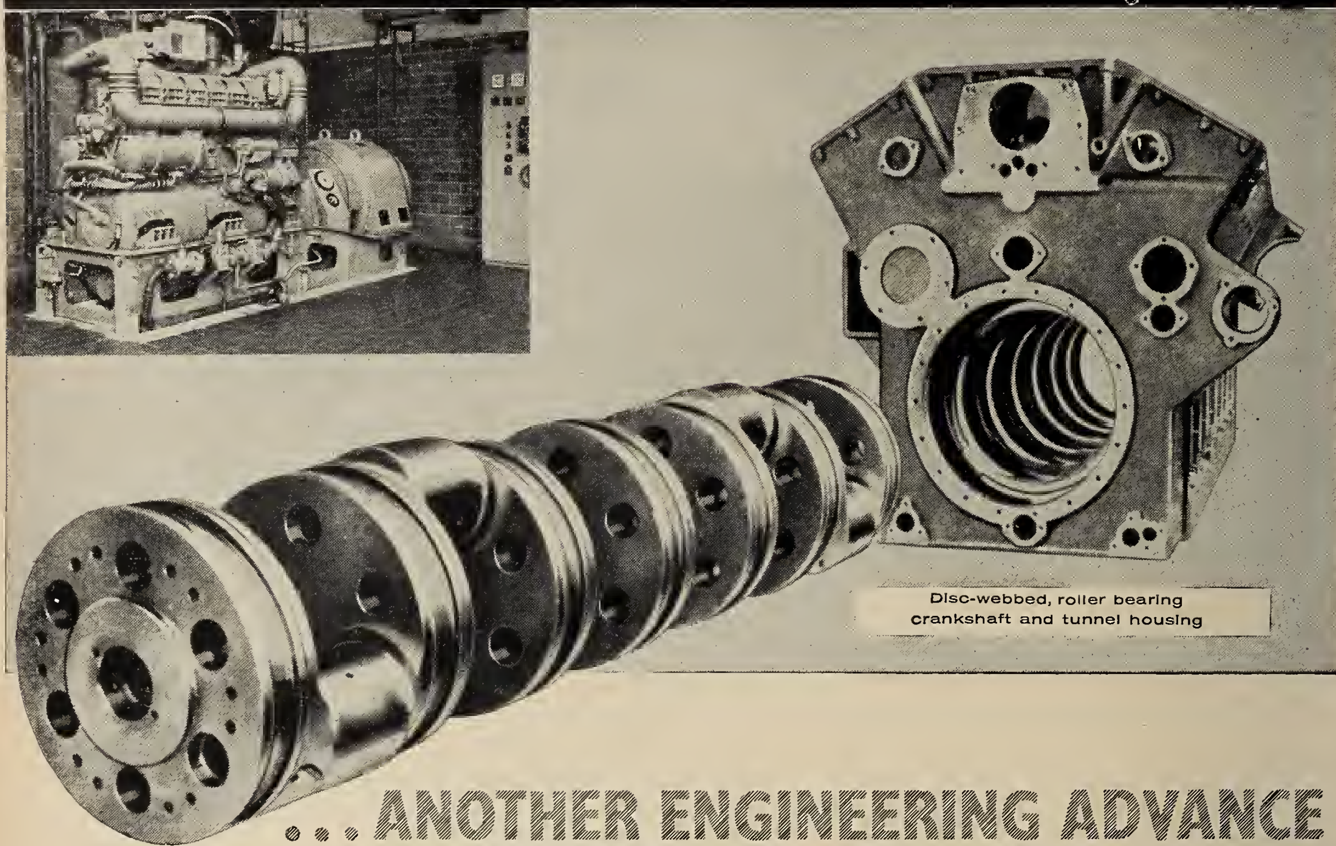
Secretary, John G. Hall, 92 Heddington Ave., Toronto, Ont.

Maybach industrial diesel engines—from 300 to 1,800 hp—can achieve 16,000 hours between major overhauls . . .



Disc-webbed, roller bearing crankshaft and tunnel housing

. . . ANOTHER ENGINEERING ADVANCE FROM BRISTOL SIDDELEY

Bristol Siddeley Engines Limited produce Maybach* diesel engines. Covering a power range from 300 to 1,800 hp, Maybach diesels are amazingly reliable and have shown that they can achieve major overhaul lives of between 12,000 and 16,000 hours.

The *proven* basic design features of the whole range (straight 4 to 16-cylinder V) are the same, and each unit can be turbo-charged, or turbo-charged and intercooled. The range operates up to 1,600 rpm and *combines the best performance and design qualities of high, medium and low-speed diesel engines:* light weight and compactness; excellent thermal efficiency; and extremely long life.

Advanced design features

The pistons are pressure-oil cooled. This gives very efficient heat dissipation and reduces liner and gas ring wear to a minimum. The roller bearing, disc-webbed crankshaft is exceptionally rigid within its tunnel housing, and in practice withdrawal is not normally necessary before 12,000 hours running. So low is big end bearing wear that in some cases the protective lead flash has been found intact when examined after 15,000 hours running!

Since the cylinder bore and stroke, and the majority of components, are identical in all models, spares stocks are considerably reduced. And during servicing semi-skilled labour can be used because great thought has been given to easy accessibility and removal of components.

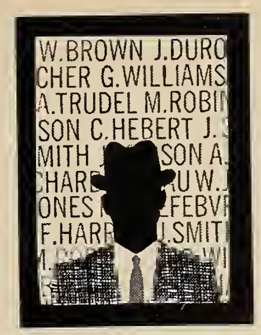
World-wide application

Bristol Siddeley Maybach diesel engines are designed for a wide variety of industrial applications, from stationary and mobile light and power generator sets to oil-drilling rigs and pumping stations. Maybach diesel engines are in service all over the world and have built up an unrivalled record for reliable and economic operation.

For further information please write to: Bristol Aero-Industries Limited, 200 International Aviation Building, Montreal 3. Tel.: UNiversity 6-5471.

**Under licence from Maybach-Motorenbau GmbH*

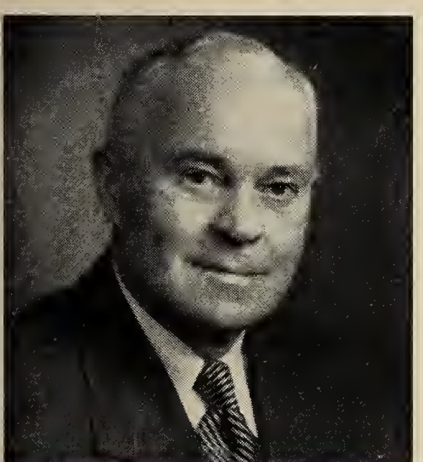
BS BRISTOL SIDDELEY ENGINES LIMITED



Personals

Otto Holden, Hon. M.E.I.C. (Toronto '13), chief engineer of the Hydro-Electric Power Commission of Ontario, has retired after 47 years of service. A major influence in hydro-electric development throughout Ontario, Dr. Holden has been intimately associated with the design and construction of over 300 hydraulic projects in the province. Significantly, he leaves the work at which he has had such success after completing the largest project of his career, the long-term planning and design of the St. Lawrence power project.

Dr. Holden began his career with the Commission in 1913, the year he graduated from the University of Toronto. In 1918 he was placed in charge of the design of hydraulic plants, the most outstanding of which were the Nipigon River plant at Cameron Falls and the Sir Adam Beck-Niagara generating station No. 1 at Queenston. Named deputy head of the hydraulic department in 1924, he supervised the first complete development of an interprovincial power site, on the Ottawa River at Chats Falls.



Dr. Otto Holden, HON. M.E.I.C.

As chief hydraulic engineer from 1937-47, Dr. Holden served with distinction on the International Committee, charged with the design and construction of the remedial works in the Niagara River. In 1947, appointed assistant general manager of engineering, he continued to develop Ontario's water power resources and in the following ten years played a key role in speeding some 14 new major power sources into operation. In renaming the La Cave generating station The Otto Holden Generating Station in 1952, the Commission signally recognized Dr. Holden's important contribution. He was appointed to succeed Richard L. Hearn as chief engineer in 1957.

A distinguished professional engineer, Dr. Holden has been honoured with positions of leadership in professional societies for many years. He is a past councillor of the Institute; a past director of the American Society of Civil Engineers, of the American Institute of Electrical Engineers, and of the Senate of the University of Toronto. He is also a past president of the Engineering Alumni Association of the University of Toronto and a past president of the Royal Canadian Institute.

Dr. Holden was awarded Honorary Membership in the Institute in 1960.

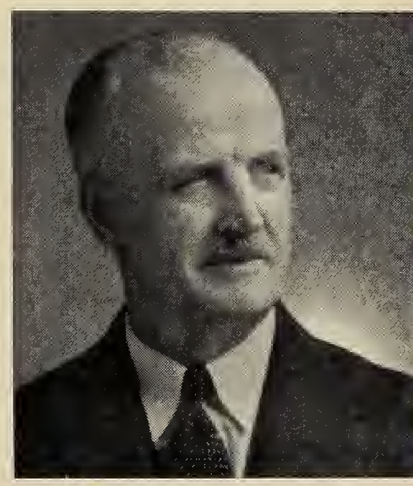
Huet Massue, M.E.I.C. (Ecole Polytechnique '13), General Manager of the Lower St. Lawrence Gulf Development Association and former director of Atomic Energy of Canada Limited, was recently elected to the board of EDITORIAL ASSOCIATES LIMITED, public relations counsel.

E. D. Gray-Donald, M.E.I.C., (McGill '26), Vice-President, Administrative Services, The Shawinigan Water and Power Company, has been elected an HONORARY MEMBER of the Canadian Transit Association for "outstanding service to the Canadian transit industry". Mr. Gray-Donald first became associated with the Canadian Transit Association while with the Quebec Railway, Light and Power Company and was subsequently elected to the Executive Committee and served as President from 1946 to 1948.

Charles H. Pigot, M.E.I.C. (McGill '26) has been named ASSISTANT CHIEF ENGINEER of the Power Development Division of the Quebec Hydro-Electric Commission.

T. W. B. Lazenby, M.E.I.C., has been made DESIGN ENGINEER III in the Engineering Division of The Consolidated Mining and Smelting Company at Trail, B.C.

C. J. MacKenzie, Hon. M.E.I.C. (Dalhousie '09), a past president of the Engineering Institute of Canada and former president of the National Research Council, has been appointed to the Ottawa Advisory Board of The Toronto General Trusts Corporation. Dr. MacKenzie has



C. J. MacKenzie, HON. M.E.I.C.

had a distinguished career, as dean of the faculty of engineering at the University of Saskatchewan, president of the National Research Council, president of Atomic Energy of Canada Ltd., and, currently, chancellor of Carleton University.

Dr. MacKenzie has been the recipient of honorary degrees from the universities of Dalhousie, Queen's, Western Ontario, Algiers, Saskatchewan, McGill, Laval, Cambridge, British Columbia, Princeton, Toronto, Nova Scotia Technical College, and the University of Montreal.

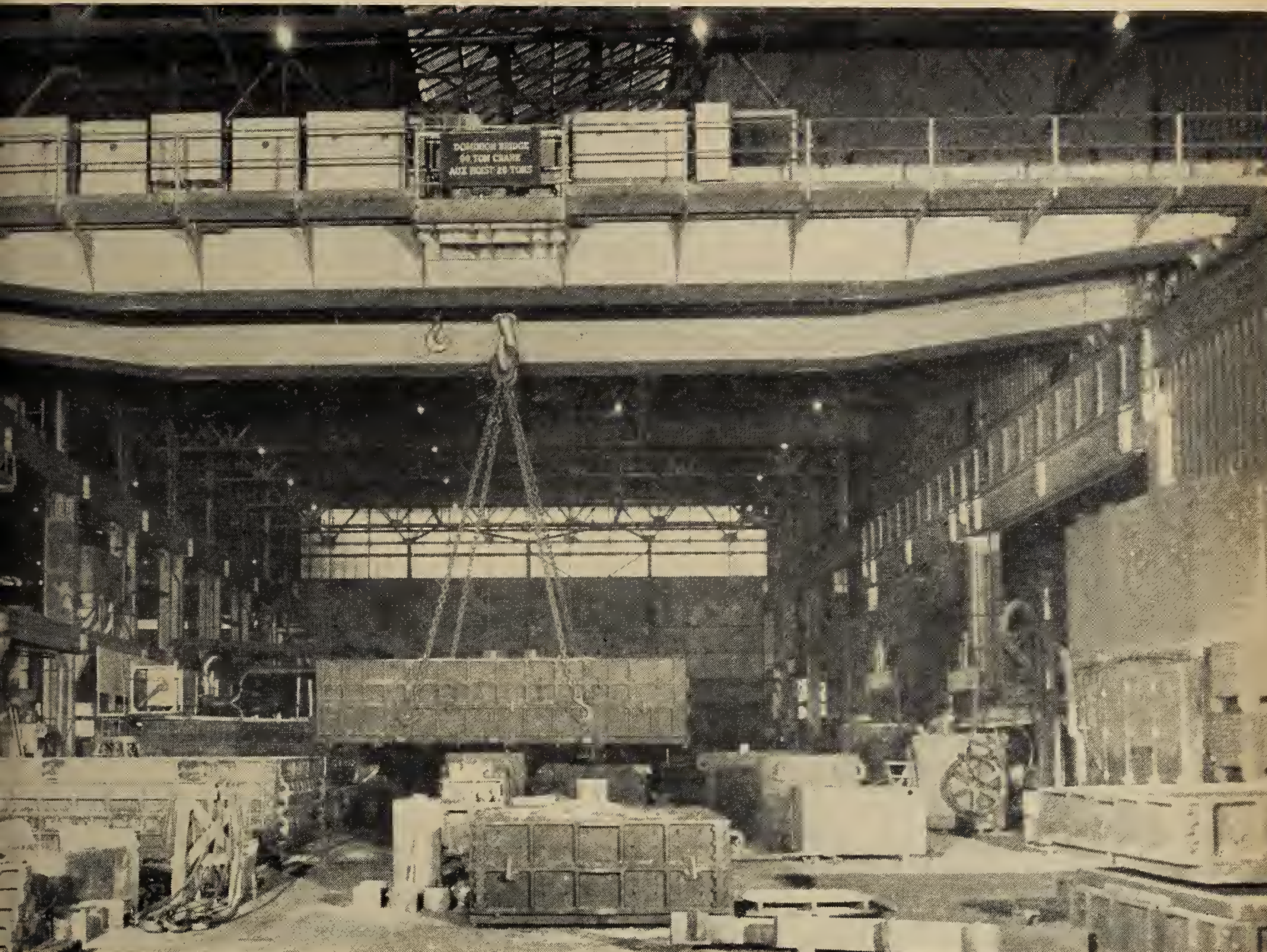
Ronald W. Dunlop, M.E.I.C. (Toronto '27) has been appointed GENERAL MANAGER of the manufacturing department, Imperial Oil Limited.

Wilfred N. Hall, M.E.I.C. (U.B.C. '29), President of Dominion Tar and Chemical Co. Limited, Montreal, has been elected PRESIDENT of The Chemical Institute of Canada.

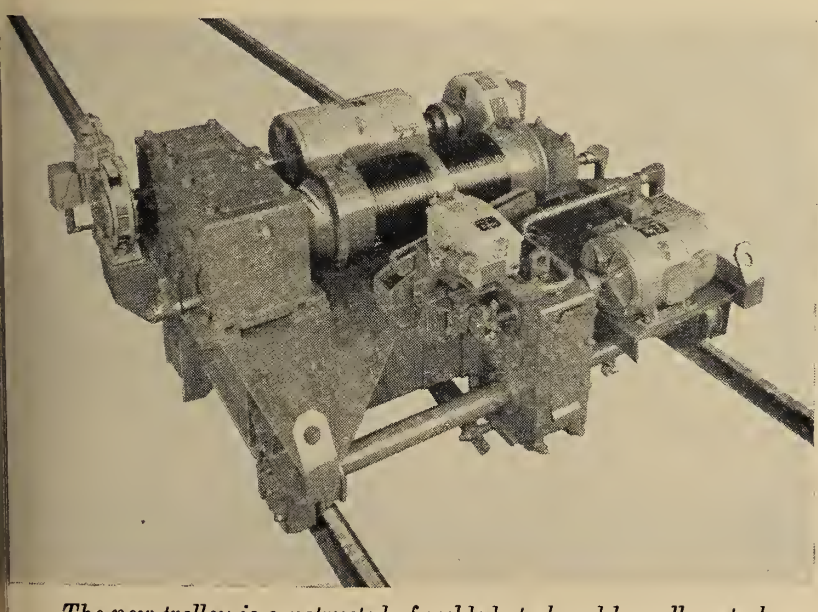
Dwight S. Simmons, M.E.I.C. (Queen's '32), President of the Association of Pro-

(more Personals on page 112)

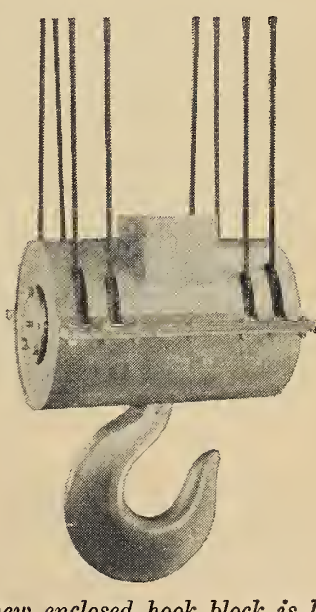
with new standards



One of the new cranes installed in a foundry. This 90-ton unit, equipped with open type cab incorporates an auxiliary 20-ton hoist.



The new trolley is constructed of welded steel and has alloy steel gearing. Split oil seals are used on projecting shafts and the drum. Large gear case inspection cover simplifies maintenance.



The new enclosed hook block is lighter and more compact.

• PERSONALS

(Continued from page 109)

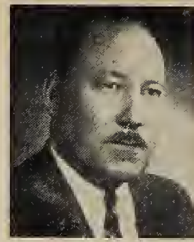
fessional Engineers of Ontario, has been named a DIRECTOR of Imperial Oil Limited.

J. H. Palmason, M.E.I.C. (Manitoba '33) is the EXECUTIVE VICE-PRESIDENT of L. Gordon Tarlton Ltd., general contractors, Montreal, by recent appointment. Mr. Palmason was formerly Vice-President and General Manager of Siporex Ltd., a subsidiary of Dominion Tar & Chemical Co. Ltd.

J. E. Dumontier, M.E.I.C. (Ecole Polytechnique '35), Director of the Engineering Branch of the Board of Transport Commissioners, has been appointed DEPUTY CHIEF COMMISSIONER of the Board.

Andrew M. Swan, M.E.I.C. (Manitoba '39) is RESIDENT MANAGER of the Richmond Pulp and Paper Co. of Canada, Ltd. mill at Bromptonville, Quebec by recent appointment.

E. Rohatynski, JR.E.I.C. (Manitoba '50) has been appointed CONSTRUCTION ENGINEER IV in the Engineering Division of The Consolidated Mining and Smelting Company, Kimberley, B.C.



G. E. Humphries, M.E.I.C.

W. L. Wardrop, M.E.I.C.

George E. Humphries, M.E.I.C., and W. L. Wardrop, M.E.I.C. (Manitoba 39), Presidents respectively of M. M. Dillon and Company Limited and W. L. Wardrop and Associates (Management) Limited, announce the formation of DILLON - WARDROP ASSOCIATES, Consulting Engineers, Winnipeg. The two firms will continue to operate independently as in the past but will combine in the new firm for large engineering projects in Western Canada.

A. J. Groleau, M.E.I.C.

A. J. Groleau, M.E.I.C (McGill '28), vice-president of the Corporation of Professional Engineers of Quebec, has been named VICE-CHAIRMAN of the Trans-Canada Telephone System. Mr. Groleau is Vice-President and General Manager of Bell Telephone's Toll Area.

John A. McRae, M.E.I.C. (Toronto '49) has taken up the duties of CHIEF ENGINEER with the Noront Steel Construction Co. Ltd., Sudbury, Ont. He was formerly with the Dominion Bridge Co. Ltd.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Address all information to: *The Engineering Journal,* Editorial, 2050 Mansfield Street, Montreal, Que.

Lloyd K. Hart, M.E.I.C. (Toronto '40) has been appointed GENERAL MANAGER of Regent Electric Supply Company, Division of Union Electric Supply Co. Limited, Toronto.

L. K. Hart, M.E.I.C.

Donald A. Burris, M.E.I.C. (N.S.T.C. '45) is GENERAL SALES MANAGER, Canadian Ingersoll-Rand Co. Limited, following a recent appointment.

D. A. Burris, M.E.I.C.

R. J. Balfour, M.E.I.C. (McGill '46), formerly with Fraser-Brace Engineering Company Ltd., has opened a new construction office for BROWN & ROOT, LTD., Montreal.

R. J. Balfour, M.E.I.C.

J. B. Goodfellow, M.E.I.C. (McGill '46) has been elected ALDERMAN in the City of Dorval, Quebec. Mr. Goodfellow is Transite Pipe Staff Manager of the Montreal branch, Canadian Johns-Manville Co. Limited.

J. B. Goodfellow, M.E.I.C.

Glenn C. Ritcey, M.E.I.C. (McGill '48) is VICE-PRESIDENT AND GENERAL MANAGER of Radar Pneumatics (Eastern) Ltd. following a recent appointment.

L. S. Love, JR.E.I.C.

L. S. Love, JR.E.I.C. (McGill '51) has been appointed EASTERN SALES ENGINEER for Separator Engineering Ltd. He was previously associated with General Electric and Infilco as Canadian District Manager.

R. G. Gallinger, JR.E.I.C. (Toronto '56) has been transferred from the RCAF 4(F) Wing in Germany to the Central Experimental and Proving Establishment, Ottawa, where he will act as a pilot on test and development projects. He has recently been promoted to the rank of FLIGHT LIEUTENANT.

P. E. Coulter, JR.E.I.C.

Philip E. Coulter, JR.E.I.C. (McGill '56) has been appointed Canadian DESIGN AND SALES ENGINEER for Waterman-Waterbury Co., Minneapolis, Minn.

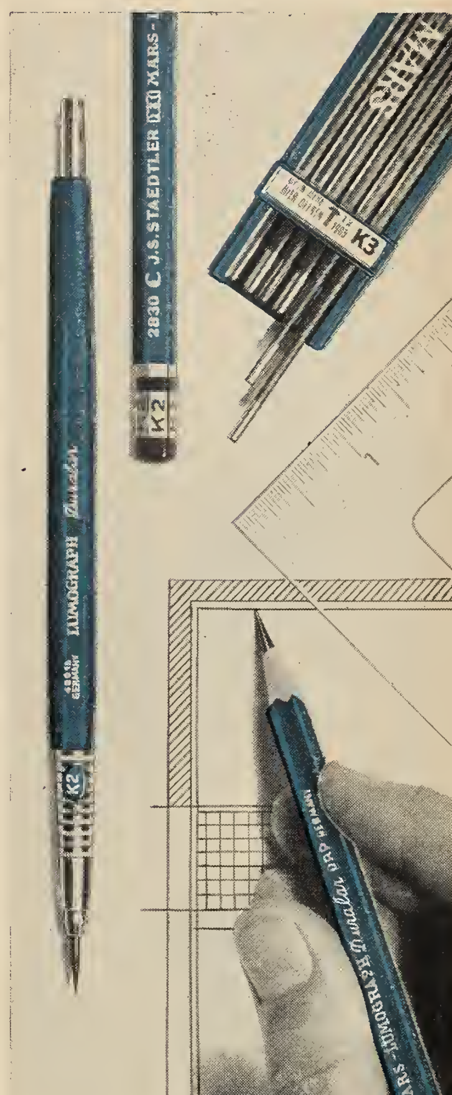
D. B. Barry, M.E.I.C.

Donald B. Barry, M.E.I.C. has been appointed MANAGER OF PLANT ENGINEERING for Dominion Engineering Works Ltd., Montreal.

Frederic Dreville, M.E.I.C. has been appointed CHIEF ENGINEER of the hydraulics department, Surveyer, Nenninger & Chenevert, Montreal.

Richard J. Joy, M.E.I.C. (McGill '45) has joined the INDUSTRIAL DEVELOPMENT BANK as an Investigating Officer and is now attached to their Montreal office.

Maurice Decarie, M.E.I.C. (McGill '45) has been appointed VICE-PRESIDENT AND GENERAL MANAGER of Domaine d'Esterel Inc. Mr. Decarie is President of Omega Construction Company Limited.



Other Societies

New Volume of Dechema Monographs

"Fortschritte der Destilliertechnik" (Progress in Distillation Engineering) is the title of Volume 37 of the Dechema Monographs. It contains an account of three comprehensive experimental investigations on rectifying columns—the first, on the properties of two-phase flow in rectification in packed columns; the second, on control problems in continuous distillation columns; the third, on application of the similarity theory to the processes in rectification columns.

French Magazine on Industrial Design

A magazine on industrial design, published in Paris, is available for circulation in Canada. Entitled "Esthetique Industrielle", the publication includes photographs and documentation on new designs and discussion of design problems.

Soviet Research Published in Translation by ASME

Recent Soviet engineering research is described in a new translation entitled **Friction and Wear in Machinery**, published by the American Society of Mechanical Engineers. Included in the volume are fifteen articles on a wide range of topics from hydrodynamic lubrication and bearing performance to boundary lubrication, dry friction and wear. Copies are available at $7.50 per copy from the Order Department, ASME, 29 West 39th Street, New York 18, New York.

World Conference on Earthquake Engineering

Organized by the Science Council of Japan, the Second World Conference on Earthquake Engineering was held at Tokyo and Kyoto, Japan, July 11-18. Dr. Sheldon Cherry, Civil Engineering Department, University of British Columbia, participated in the conference, representing the National Research Council of Canada.

AIEE Pacific General Meeting

The 1960 Pacific General Meeting of the American Institute of Electrical Engineers was held in San Diego, California, August 8-12. One of the chief items on the technical program was the meeting of the Aero-Space Committee and their discussion of "Electrical Frontiers of the Space Age". Technical papers were presented in three general groups: Communication and Electronics; Applications and Industry; Power Apparatus and Systems.

Joint Automatic Control Conference

Massachusetts Institute of Technology, Cambridge was the scene of this year's Joint Automatic Control Conference, September 7-9, sponsored by the American Society of Mechanical Engineers with the cooperation of the Boston section and participating societies. Conceived to reduce the overlap of conferences on control sponsored by individual societies, it is understood that there will be no other national conferences on control. At this conference a report was delivered on the First IFAC Congress held in Moscow, June 27 to July 2.

Ready-Mixed Concrete Convention

The first convention of the Ready-Mixed Concrete Association of Ontario was held September 18-20 at Delawana Inn, Honey Harbour, on Georgian Bay, about 100 miles north of Toronto. One of the highlights of the convention was an equipment display by associate members.

Brno Trade Fair, September 11-25

The gates of the International Trade Fair in Brno, Czechoslovakia opened on September 11 to a giant exhibition of machine tools, electrical and electronic devices, raw materials, semi-products and various products of the engineering and metallurgical industries. More than 30 countries, including Canada, are exhibiting at the fair. AECL is displaying a wide range of special instruments which it has developed.

Coming Events

Power Conference (ASME with AIEE), Philadelphia, Bellevue Stratford Hotel, September 21-23.

3rd Canadian National Material Handling Show and Conference, Montreal, Show Mart, September 26-30.

(Continued on page 116)

The Associations and Corporation

The winners of this year's undergraduate scholarships awarded by the Association of Professional Engineers of Ontario for study at the University of Toronto and Queen's University, Kingston have been announced.

The scholarships, of $250 each, are awarded annually in the first three years at Toronto and Queen's to the student who, taking honours in engineering, obtains the highest standing in his work in the academic year.

The University of Toronto scholarship winners this year are:

First Year: Yiu Chung Li, Toronto, civil

Second Year: G. M. Bragg, Islington, mechanical

Third Year: J. G. Heller, Toronto, engineering physics.

Recipients of A.P.E.O. scholarships at Queen's University are:

First Year: Edward Langstaff, Rainy River

Second Year: Stanley E. Frost, Port Hope

Third Year: D. Russell Morton, Kingston.

Obituaries

William Douglas Adams, M.E.I.C., a member of the Institute since 1908, died in Toronto on June 30, 1960.

Mr. Adams received his degree in engineering from the Royal Military College of Canada in 1908. After work on various engineering projects, Mr. Adams enlisted in the Victoria Rifles of Canada and went overseas. In April of 1917 he was appointed Brigade Major of the First Canadian Infantry Brigade where he served until May 1918. At this time he was promoted to General Staff Officer, Fifth Canadian Division. He took a staff course at Cambridge and acted as second-in-command of Canadian headquarters at Seaford.

Returning to Canada Mr. Adams became a partner of Adams Brothers in Toronto, later joining the Toronto Transportation Commission. Subsequently he was associated with Walter J. Francis and Company of Montreal, and with A. Bentley & Sons, Toledo. Mr. Adams joined the Algoma Steel Corporation, Toronto in 1939 and retired as a piling engineer from that company in 1957.

A Member of the Council of the Institute from the Sault Ste. Marie Branch in 1958-60, Mr. Adams was a Life Member of both E.I.C. and the Association of Professional Engineers of Ontario.

Robert W. Angus, Hon. M.E.I.C., a Life member of the Institute, former senior professor at the Faculty of Applied Science, University of Toronto, and distinguished consulting engineer, died June 30, 1960.

Professor Angus graduated from the School of Practical Science in 1894. Appointed lecturer at the University of Toronto in 1900, he enjoyed 47 years of association with the university and carried on an active consulting practice until last year. He was instrumental in establishing the mechanical engineering department as a separate entity at the University of Toronto, and during his early years there was responsible for the design and equipment of the mechanical laboratories. Professor Angus directed all the heat-engine and hydraulic work done at the university.

A pioneer in the use of models for the study of water flow and elimination of ice troubles in hydraulic plants, Professor Angus maintained a large consulting practice, specializing in pumps and turbines. His published works include "Theory of Machines" (1915), "Hydraulics for Engineers" (1931), and numerous technical papers.

Over the years Professor Angus' distinction in the profession has been repeatedly recognized. Honorary Memberships were bestowed upon him by the Engineering Institute of Canada, in 1937; the American Society of Mechanical Engineers, in 1940; and the American Water Works Association, in 1945. The latter association honoured Professor Angus in 1942 with its George Warren Fuller Award for his contributions to the field of hydraulics. In 1957 The Engineering Institute of Canada established a medal to commemorate his name.

Ernest E. Brydone-Jack, M.E.I.C., former professor of civil engineering at the University of New Brunswick, Dalhousie University, and the University of Manitoba, died at his home in Joshua Tree, California, on May 23, 1960.

A graduate in Arts from the University of New Brunswick, Mr. Brydone-Jack received his civil engineering degree from Rensselaer Polytechnic Institute in 1894. From 1901-05 he was professor of engineering and Dean of the Engineering Faculty at the University of New Brunswick; during the period 1905-07 he held a professorship at Dalhousie; and from 1907-17 he was at the University of Manitoba.

For the next seventeen years, 1917-34, Mr. Brydone-Jack acted as Superintending Engineer, Public Works of Canada, for the Prairie Provinces, British Columbia, the Northwest Territories and the Yukon. In 1926 his Alma Mater, the University of New Brunswick, conferred the Honorary Degree of Doctor of Science upon him.

Mr. Brydone-Jack was granted Life Membership in the Institute in 1938. He was a Past President and Life Member of the Association of Professional Engineers of British Columbia and a Life Member of the American Society of Civil Engineers.

Charles Peter Edwards, M.E.I.C., former Deputy Minister of Air Services, Ottawa, and a key figure in the establishment of Canada's radio and wireless networks, died in Ottawa, July 14, 1960. He was 74.

Born and educated in Wales, Mr. Edwards' experience in wireless communication began in 1903 when Guglielmo Marconi erected a demonstration station at Chester, England. He became a Junior Technical Assistant on Marconi's staff and, in 1904, came to Canada to supervise the construction of stations at Camperdown, Nova Scotia and Sable Island. In 1909 he was appointed director of radio in the old Marine Department, later becoming director of the Radio Branch of the Department of Marine and Fisheries, and subsequently Director of Radio for the Dominion Government.

During World War I he held the rank of lieutenant-commander with the Naval Vounteer Reserve.

In 1941 Mr. Edwards was appointed Deputy Minister of Air Services for the Department of Transport, Ottawa, to direct the radio, civil aviation and meteorological services of Canada. He played a large part in establishing the Commonwealth Air Training Plan during World War II.

Mr. Edwards retired from his post as deputy minister of Air Services in 1951 after 41 years of government service. In that year he was also made a Life Member of the Institute.

James John Haffey, M.E.I.C., resident manager at the Valleyfield plant of Canadian Schenley Ltd., died suddenly on July 10, 1960, at the age of 43.

A 1939 graduate in chemical engineering from the University of Toronto, Mr. Haffey later became chief chemist with Canadian Industries Ltd. He subsequently joined Defence Industries Ltd. in Valleyfield as laboratory supervisor. In 1943 he was employed by the Polymer Corporation, and was made assistant mechanical engineer at the Sarnia, Ontario plant. He became associated with Canadian Schenely in 1945.

Mr. Haffey held memberships in the Corporation of Professional Engineers of Quebec and the Chemical Institute of Canada.

J. Donald Rice, M.E.I.C., Assistant Chief Engineer of the Pipe Line Division of Imperial Oil Ltd., died on June 11, 1960. He was 47.

Educated in Montreal and Welland, Mr. Rice graduated from McGill University in 1935 with a degree in civil engineering. Before joining the International Petroleum Co. Ltd., Peru in 1938, he worked in various survey parties and for the civil service in Ottawa.

In 1950 Mr. Rice returned to Canada from South America and worked on the Sarnia Products Pipe Line, for Imperial Oil, Toronto, as Chief Dispatcher. He spent five years in Waterdown, Ontario and then was transferred to Toronto in 1957, as Chief Engineer of the Pipe Line Division.

● OTHER SOCIETIES
(Continued from page 114)

Rubber and Plastics Conference (ASME), Erie, Pa., Hotel Lawrence, October 9-12.

1960 National Electronics Conference and Exhibition, Chicago, Hotel Sherman, October 10-12.

Human Factors and Bioastronautics Conference (American Rocket Society), Dayton, Ohio, October 10-12.

Seventh Symposium on Vacuum Technology (American Vacuum Society, Inc.), Cleveland, October 12-14.

Society of Photographic Scientists and Engineers, Washington, D.C., October 14-15.

7th Annual Joint Lubrication Conference (ASME and American Society of Lubrication Engineers), Boston, Statler-Hilton Hotel, October 17-19.

41st Convention of the Canadian Good Roads Association, Toronto, October 17-20.

Joint Meeting of the Canadian Aeronautical Institute and the Institute of the Aerospace Sciences (U.S.), Montreal, October 17-18.

Conference on Hypervelocity Projection Techniques, Denver, Colo., October 20-21.

Fuels Conference (ASME with American Institute of Mining, Metallurgical and Petroleum Engineers), Charleston, West Va., Daniel Boone Hotel, October 24-25.

Seventh Annual Computer Applications Symposium, Chicago, Ill., October 26-27.

13th Regional Meeting of the American Concrete Industry and Joint ACI-ASME Research Session, Pioneer Hotel, Tuscon, Ariz. — October 31-November 2.

First National Die Casting Exposition and Congress, Detroit, Mich., Detroit Artillery Armory, November 8-11.

24th National Exposition of Power and Mechanical Engineering, New York Colliseum, N.Y. — November 28-December 2.

Steels for Nuclear Reactor Pressure Circuits (Iron and Steel Institute, U.K.), London, England, November 30 to December 2.

1961 SAE International Congress and Exposition of Automotive Engineering, Detroit, Mich., January 9-13, 1961.

Canadian Textile Conference, Montreal, Queen Elizabeth Hotel, February 7-9, 1961.

1st International Congress on the Mechanics of Soil-Vehicle Systems, Turin, Italy, Polytechnic Institute, May, 1961.

3rd Symposium on Information and Decision Processes, Purdue University, April 12-14, 1961.

National Industrial Production Show of Canada, Toronto, Industry and Coliseum Buildings, C.N.E. Park, May 8-12, 1961.

News of the Branches

Cape Breton

L. R. Boutilier, M.E.I.C., *Correspondent*

A LOBSTER PARTY, an annual affair at this time of year, brought 85 members and guests together on June 15, for an evening of feasting, cards, and good fellowship.

This outing at the Y.M.C.A. camp at Barrachois, about 20 miles from Sydney, was the final meeting of the season.

Lakehead

P. W. Pinn, M.E.I.C., *Correspondent*

THE ANNUAL MEETING of the Lakehead Branch was held on June 20 at the Port Arthur Country Club, and the following people were elected to the 1960-61 executive of the branch: John A. Brown, chairman; Philip W. Pinn, vice-chairman; Ernest B. Cashton, secretary-treasurer; Wayne P. Cheney, A. E. Meade, and Bruce P. Menlove, Fort William directors; Laurie E. Hardman, John C. Gilmore, Reginald Williamson, Port Arthur directors; Robert Hamilton, Eastern representative.

Mr. Douglas Fisher, Member of Parliament from Port Arthur, discussed the subject The Engineer and The Politician, stressing the need for more participation of engineers in public life.

Niagara Peninsula

THE SEVENTH ANNUAL Professional Engineers' Ball will be held again this year at Prudhommes' Garden Hotel on the Queen Elizabeth Way at Vineland, on Friday, September 30, 1960.

Mart Kenney and his orchestra will provide the dance music and there will be organ music during the cocktail and dinner hours. The floor show at intermission will be given by the Paul Brothers and Shirley.

The program is to start with cocktails at 6:00 p.m., followed by dinner at 7:00 p.m. and dancing at 9:00 p.m. Tickets will be $10.00 per couple.

J. H. Travers, JR.E.I.C.

Sarnia

Paul Donato, M.E.I.C., *Correspondent*

A FIELD TRIP to London, Ontario, June 16, allowed 38 members to visit the plants of the Wolverine Tube Mill of Calumet and Hecla and the Canada Vulcanizer Equipment Company. Groups of four and five engineers were guided around the plants to see first the extrusion and drawing processes in the Wolverine Tube Mill, then the production of Lo-Fin and Hi-Fin tubes at the C.V.E. plant.

A dinner at a London Golf Club followed, where the Calumet and Hecla personnel acted as hosts. Many who took the trip expressed the hope that more trips of a similar nature could be had in the future.

Engineers' Wives' Associations

THE FOURTH ANNUAL MEETING of the Associations, held in Winnipeg at the time of the Annual General Meeting of the Institute, brought 100 ladies together at the Royal Alexandria Hotel, May 27th.

Mrs. W. L. Bunting, Past President of the Winnipeg Professional Engineers' Wives Association and Chairman of the meeting, welcomed the many members and guests and asked for a reading of the annual reports from the different associations.

A number of interesting facets in association activities were illuminated by these reports. Mrs. R. H. Stevenson, speaking for the Hamilton Branch, discussed their bursary fund, pointing out that no fund-raising is done but $1 of the $5 fees is put aside for the bursary fund. A $50 bursary for a McMaster student in engineering has been made available each year until this year. With accumulated surpluses, it is possible to celebrate the 10th Anniversary of the branch with two $50 bursaries to engineering students.

The Penticton Branch, represented for the first time at the Annual Meeting. has an active membership of 12 ladies. It has been in existence for six years. No large projects are undertaken by the group, but social evenings are held every two months, sometimes with a speaker. The branch was represented by Mrs. Amudson, President, and Mrs. R. Price, Secretary-Treasurer.

Reports were also presented by: Mrs. J. M. Reid, Border Cities; Mrs. Stuart Neil, Calgary; Mrs. E. M. Rensaa, Edmonton; Mrs. M. A. Montgomery, Kitchener; Mrs. George Hayman, London; Mrs. P. A. Lovett, Halifax; Mrs. T. F. Holmes, Montreal; Mrs. P. M. Sauder, Lethbridge; Mrs. Rex Williamson, Lakehead; Mrs. T. Foulkes, Ottawa; Mrs. R. R. Keith, Regina; Mrs. G. V. Meagher, Toronto; Mrs. R. O. Jonasson, Winnipeg.

The 20th Anniversary Luncheon of the Winnipeg Professional Engineers' Wives Association, directly following the Annual Meeting, was the occasion of an address by Mrs. E. P. Featherstonaugh. Several excerpts from the historical sketch of the Winnipeg association follow.

My interest in Engineers' Wives goes back many years, for throughout my married life my husband and I entered wholeheartedly into the University functions planned by the students; we chaperoned countless dances, and many were the romances that budded before our eyes. Thus it was that when a group decided to form their own club and asked me to act as their first President, I was very proud and happy to do so. This was to be a purely social organization, we had a little fun together, and we wanted to get to know each other better. If at any time Engineering Conventions were to be held in Winnipeg, we would have our Committees standing by ready to help in the entertainment of visiting ladies.

However, to go back to 1940 and those early days of war, it was not long before an appeal came to us from the Red Cross, and we decided that we must do something. We started two sewing groups and a knitting group, and in the first two years turned in 442 pair of pajamas and 310 articles.

Perhaps the only way in which I can possibly cover the work accomplished over the past twenty years is by simply stating facts without elaboration. Our war work, in addition to the sewing and knitting groups, included Volunteer Service given to the United Services Centre: The Blood Donor Clinic; the Men's Service Lodge. From 1940-48 we raised over $1200 to purchase flannelette and wool. From 1945-47 we purchased twenty-four radios at a cost of $543, a gift to Deer Lodge Hospital for the use of wounded veterans. We set aside $50 as a wedding gift for Princess Elizabeth. In 1950 when Winnipeg was facing a major catastrophe, we gave $300 to the Flood Relief Fund.

In January 1951, we came to the decision that as Engineers' Wives, we would further the cause of Engineering education in this province; we undertook to endow one Bursary, and in 1951, we awarded our first Bursary of $100 to an Engineering student in the University of Manitoba. Since this time, we have built up a Trust Fund of $3,550. This money has been raised by our Annual Coffee Party held in February or March. The average net take in the past five years has been $630, with a high of $780 in 1959. Thus with our Trust Fund behind us, we have doubled and quadrupled our bursaries. In 1956, 1957 and 1958 we gave two Bursaries of $100 each, and in 1959 and this year two bursaries of $200 each.

"Pyrotenax" was used for interior and exterior wiring at the O'Keefe Centre, Toronto.

• DISCUSSION

(Continued from page 98)

engine. In this sense then the use of the same basis is justified for a comparative study of the free piston engine relative to diesel and spark ignition engines. With regard to the gas turbine Mr. Cockshutt's point that the use of regenerators will greatly offset the results of a study made on the basis of the Brayton cycle is quite true. It is obvious however that with the use of such regenerators the most appealing characteristic of the gas turbine namely its simplicity is lost. It was for this reason that the author limited his study to the simple gas turbine cycle as represented on the air standard basis by the Brayton cycle.

Mr. Cockshutt's way of plotting the data from Professor London's paper was most interesting but in this connection it has to be pointed out that even in reference 15 (Professor London's paper) from which the data was taken a number of design parameters had to be neglected for the sake of clarity of representation. Fig. 1 in Mr. Cockshutt's discussion may furthermore be easily offset by the influence which the compressor compression ratio has on turbine efficiency in the low and medium power range as pointed out in the last parts of his own discussion. By increasing the compressor compression ratio for instance the turbine expansion ratio increases simultaneously which for the same power output results in more dense turbine inlet conditions and consequently lower turbine blades, therefore higher clearance loss and lower turbine and overall powerplant efficiency. If on the other hand from design considerations a higher maximum pressure is tolerable one can select a low compressor compression ratio and apply the possible increase in overall compression ratio to the diesel section only, which will not alter turbine inlet conditions appreciably but will result in a higher overall efficiency. These considerations however do not dispute the validity of Mr. Cockshutt's remarks in general.

In regards to scavenging temperatures it might first of all be pointed out that conditions in actual engines according to the assumed values are for several reasons not quite as severe as quoted. Taking nevertheless these quoted figures the challenging of the term 'cooling' air when this air is 600° hot is surely justified when speaking in terms of lubricating conditions. On the other hand this air is still considerably cooler than the exhaust gases and does therefore an efficent cooling job when considering materials being subjected to the mean gas temperature within the engine.

Referring to the turbine design it seems appropriate to consider present day gasifiers with present day turbines. Since the average expansion pressure ratio is 4 instead of 7 the turbine inlet temperatures are approximately 900° and the enthalpy drop across the turbine is lower, resulting in a smaller number of turbine stages and moreover on account of the larger specific volume at the turbine inlet, the first stage blade length for otherwise same conditions will go up and so will the efficiency as a result of this. If this should not be enough it is quite possible to reduce the turbine diameter somewhat resulting in a higher speed which according to the author's experience should not present any serious problem.

It might be stated in this connection that the best turbine the author has heard of was installed in a free piston installation having in a 2,000 hp. installation an overall efficiency of about 89% (see ref. 6). This turbine at 2,000 hp. is running with 8000 r.p.m. and installed in a German Heck-trawler requiring a very low propeller speed. It has been operated over the past two years quite successfully and it seems therefore quite reasonable to drive for instance a 500 hp. turbine, as shown in Fig. 2 of Mr. Cockshutt's discussion, at say 30,000 r.p.m.

In regards to after burning it might be pointed out that the author's designs are considerably less sensitive to downstream conditions than other designs which indicates that the designer has considerable freedom in solving new problems that may come up in the development of this new engine principle. Tests run in regard to this question indicate that a sudden reduction of the nozzle area down to 50% does not create any trouble with the designs mentioned.

MARINE AND INDUSTRIAL HIGH POWERED EPICYCLE GEARING

H. N. G. Allen and D. P. Jones,
W. H. Allen Sons & Co. Ltd., Bedford, England.
The Engineering Journal, September 1960, p. 83.

Discussion by Professor J. S. Campbell.

You have discussed how the flexible nature of the annulus enables you to secure a distributed load to several pinions. Some concern has been expressed about the possibility of failure due to fatigue under this flexing. An article entitled "Breakthrough in Mechanical Drive Design, The Harmonic Drive" by C. W. Musser in Machine Design April 14, 1960, describes a design that incorporates a flexing annulus many times as severe and it is claimed fatigue is not a particular problem. If this be true then your design is very safe.

I would be interested in an application at the other extreme end of the range, namely to accept 180 shaft horse power at 50,000 r.p.m. and convert it to an output speed of 200 r.p.m.

This application is for a marine drive, the high speed is developed by a turbine, the output speed is the desired propeller speed.

It will be necessary to provide for reversing either by (a) reversing the turbine, (b) incorporating a reverse in the gearing or (c) utilizing a fully reversing variable pitch propeller.

Keeping in mind reliability, cost, weight and size, what would be your general recommendation?

Reply by the authors

We have not read Mr. Musser's article but we can confirm that our design is safe. We have never had an annulus failure and the comparatively minute, but nevertheless necessary degree of flexibility in the rings themselves ensures that the stresses induced are very much lower than those likely to cause fatigue failure.

An application such as that suggested by Professor Campbell would involve two epicyclic gears each of about 12 in. annulus diameter. From the aspects of reliability, weight and size, reversing epicyclic gears would compare favourably with any other proposition. So far as cost is concerned, they might, in this small power, prove to be more expensive than other alternatives.

If a gas turbine is involved, direct reversing of the turbine might be difficult but a full reversing propeller is within the range of existing experience.

Again depending on the particular circumstances, a small de-clutchable Diesel engine might be incorporated for reversing only.

It is impossible to give specific recommendations without knowing the relative importance of all the factors involved.

Discussion by Professor J. F. Muir

You show an epicyclic gear connecting an axial flow water turbine and an electric generator.

1. Could you give the horsepower and speed of these units?
2. Could such a gear be designed to transmit power from a 100,000 hp. axial flow turbine running at about 85 r.p.m. to an electric generator running at faster speed?

Reply by the authors

1. 1750 hp. 165/1000 r.p.m. (See Fig. 13).
2. The largest gears of this type which have already been built are to transmit 7200 hp. with a ratio of 78/750 r.p.m. A gear to transmit 100,000 hp. at 85 r.p.m. would be much beyond present experience and might prove to be impossible.

MANAGEMENT—HORSE TRADING OR TRUSTEESHIP?

Lt. Col. L. F. Urwick,
Urwick, Currie Limited, Montreal & Toronto
The Engineering Journal, September 1960, p. 93.

Author's reply

I suspect that Mr. Gray-Donald overemphasizes the extent to which individuals in the ordinary business enterprise are motivated by consideration of profit. My experience suggests that in most enterprises these considerations are far removed from the daily routine of the individual members.

Of course profit is important. The ability to continue making a profit is a condition of survival for the business enterprise. But that does not prove that profit is the primary purpose and motivating factor of business institutions. It is, as I have pointed out, a means of measuring their success.

Mr. Gray-Donald's extension of the concept of profit motive to include most of the basic social desires which people seek to satisfy in their work has interesting implications in relation to government enterprises, military forces, charitable institutions and so on. Members of such institutions cannot be inspired by the profit motive as defined by Mr. Gray-Donald and his argument seems to imply that it is therefore impossible to have a successful management team in such cases. However, there is no lack of examples showing that in practice this is not true.

LIQUID PETROLEUM GASES AS FUELS FOR AUTOMOTIVE ENGINES

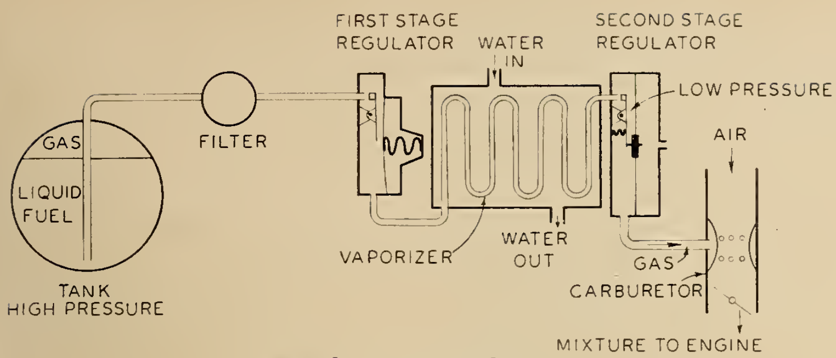
H. A. Spencer, M.E.I.C.,
Research Council of Alberta, Edmonton.
The Engineering Journal, July 1960, p. 62.

Author's reply:

Prof. MacHardy very kindly points out the main advantage of the LPG carburetion which gives it its good burning qualities and ideal distribution through the various cylinders. With regard to the lean quality of the propane in a dual-fuel situation it appears to me that a slightly greater quantity of a diesel fuel may be necessary to support combustion adequately, that is during idling the relative proportion of diesel to propane might be higher than it would be during the full load condition, and it will be interesting to do further research on the subject to discover what proportions of propane and diesel will be necessary to achieve ideal burning characteristics under all conditions. Mr. MacHardy's further suggestion of utilizing a fuel injection system appears to be the ideal answer to problems in pressure control, but necessarily poses other problems in metering a non-lubricating material.

Prof. Green asks why power increases were so large in dual-fuel installations. As mentioned in the paper the 55 HP and 103 HP each were obtained on a wheel dynamometer at 30 MPH. Power was transmitted through a torque converter to the rear wheels and actual engine horsepowers may have been within the range of 125 to 165 HP. Also in this regard the usual high peak of pressure which is associated with diesel engines directly after injection

FIGURE I. LPG CARBURETION



A revised Figure 1. is shown.

was flattened off to a certain extent and the engines sounded much smoother. It is the intention during further research to investigate the pressure phenomenon of combustion under both conditions. Also Mr. Green suggests that one would use the cheaper fuel as much as possible. However there are maintenance costs and installation costs which must be added to the cost of the cheaper propane. Three criteria are important in the consideration of this technique— 1. Fuel cost, 2. Power, and 3. Smoke production. Probably a proper balance between all three cannot be achieved by utilizing the maximum quantity of propane and it therefore will be necessary to discover the optimum conditions.

JOINTS IN PRECAST CONCRETE BUILDING FRAMES

E. M. Rensaa, M.E.I.C.,
Rensaa & Minsos, Edmonton.
The Engineering Journal, August 1960, p. 64.

Author's reply

The two points mentioned by Dean A. E. Macdonald are well worth consideration and may be answered as follows:

The type of temporary support shown was decided on after comparison with some other alternatives. It has the advantage of providing automatically the same elevation of both ends to be spliced without any special adjustment. Exactness in that respect is very important for providing good appearance. Furthermore, the time required by the erection crew for placing the centre beam is an absolute minimum. It is also thought that a bottom support gives less obstruction to welding work.

There is no doubt that the type of temporary support mentioned by Dean Macdonald would work too. It is more difficult to say what the comparative costs of the two alternatives would be.

Regarding welding of reinforcing bars, the same concern indicated by Dean Macdonald is shared by the writer. There is considerable uncertainty of how much stress can safely be allowed in a welded reinforcing bar of unknown carbon content and especially when field welded. The writer has, therefore,

not used welding when the tensile stress in the bar would be near the ordinary allowable for reinforcing steel. At or near the point of inflection, however, the maximum stresses in horizontal bars are generally low. The same applies also to bars bent up for taking shear. All these bars are in most cases oversized at this point. Since the unit stresses in these bars are generally low, the writer has considered it safe to allow welding. If high stresses were to be allowed, it should only be based on results of tests with the kind of steel used and special precautions should be taken in all cases especially for field welding.

In connection with welding of reinforcing steel, it might be of interest to read a paper, "Composite Construction in Precast and Cast-in-place Concrete" for March 1960 in Civil Engineering, A.S.C.E., by Arthur F. Anderson, F., A.S.C.E. He reports some strength tests showing that it is possible to obtain the full tensile yield point stress for bars of intermediate grade and with carbon contents from 0.3 to 0.6%. Special electrodes are necessary and preheating and controlled cooling is also important to obtain such good results. The writer thinks it might often be difficult to obtain sufficiently good field practice with such welding.

It is generally assumed that welding becomes difficult when the carbon content of steel exceeds about 25%. Other alloy additives such as Manganese have also an influence on weldability. If welding or reinforcing steel becomes more common than at present, it will be necessary for the rolling mills to pay more attention to the chemical composition of reinforcing steel.

Even when the ordinary intermediate grade reinforcing steel is used for the ordinary beam reinforcement and welding of such steel is considered inadvisable, it would be possible to use this type of joint. The ordinary intermediate grade reinforcing could be stopped at the end of the precast members, and special splice bars of structural grade or milder could be used for the welded connection. These splice bars needed only to extend far enough into the beam ends to develop the bar strengths by bond. Plain bars, not necessarily of circular cross section, could be used for that purpose. The quantity of such splice steel would not be very high and should not be unduly difficult to obtain. It is, therefore, clear that the type of joint shown could be used also in such cases where stresses are so high that welding must develop almost the full bar strengths.

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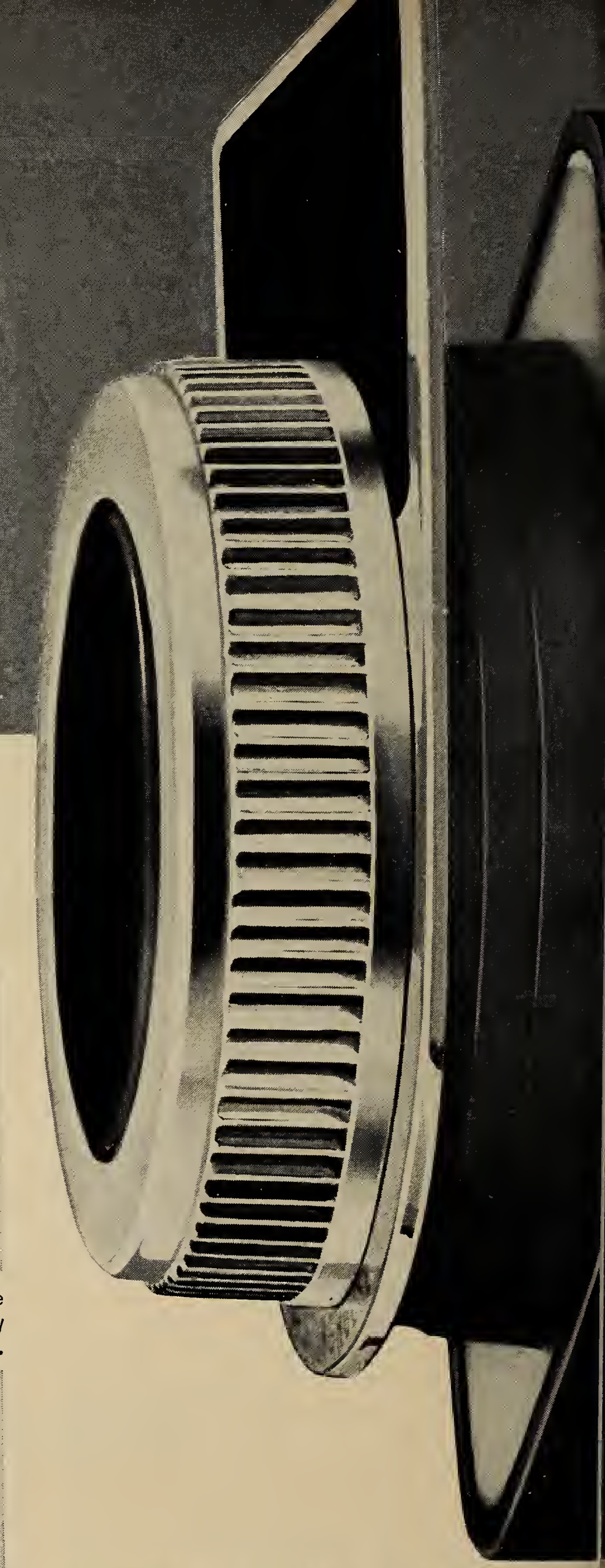

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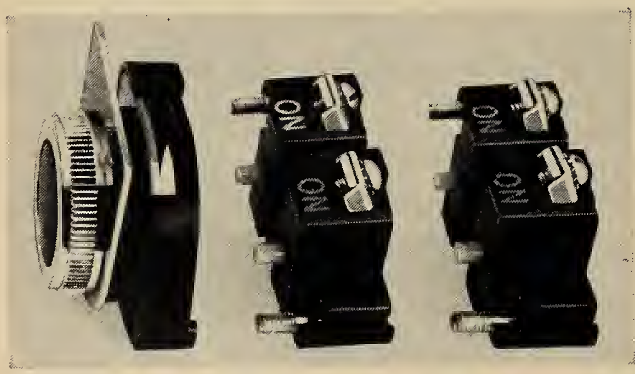

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Library Notes

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THERMODYNAMICS.

A graduate, or advanced undergraduate, introduction to thermodynamics, using a postulational approach, rather than the conventional inductive presentation. The author proceeds from a few basic concepts and postulates to develop a self-contained, simple, logical theory of thermodynamics. He shows how the whole subject is a direct consequence of these postulates. In addition to the traditional topics of thermodynamics, the author also covers such subjects as stability, second-order phase transitions, fluctuations, and irreversible thermodynamics. (H. B. Callen. New York, Wiley, 1960. 376 p., $8.75.)

BASICS OF FRACTIONAL HORSEPOWER AND REPAIR.

A working explanation of the principles of operation of the fractional horsepower motors in such common use, and the basic procedures for servicing and maintaining them. The types of motor covered include; split-phase, capacitor, repulsion, shaded-pole, universal, and three-phase. Other chapters discuss: enclosure and mounting characteristics; windings; testing; care and maintenance; control devices; motor protective devices.

The material is presented in the "picture-book" method often used by this publisher. (Gerald Schweitzer. New York, Rider, 1960. 168 p., $3.90.)

STRENGTH OF MATERIALS.

An introduction, at the undergraduate level, to the problems of stress analysis. Worked examples and problems are included. Both elastic and plastic strains are discussed, and other topics covered include problems of thin walled tubes in bending and torsion; the principle of virtual work; strain and complimentary energy, vibrations and impact stresses.

This is the first part of a completely revised edition of Case's Strength of Materials. A second volume, Advanced Strength of Materials, is to be published later. (John Case and A. H. Chilver. Toronto, Macmillan, 1959. 390 p., $6.00.)

NUCLEAR ENGINEERING MONOGRAPHS.

The volumes listed below are three in a series intended for students and others requiring a broad understanding of the topics of nuclear engineering outside their own field of study.

APPROACHES TO THERMONUCLEAR POWER.

The points in favour of the thermonuclear reactor for economic power production are discussed. An account is given of the experimental approaches to this problem, and the results obtained, including the linear pinch, the toroidal machine and the mirror machine. Methods of heating, confining and isolating the hot fuel are explained, as are the methods used to reduce the effects of the instabilities developed. A bibliography is included. (R. F. Saxe. London, Temple, 1960. 65 p., 12/6.)

NUCLEAR RADIATION MEASUREMENT.

The ways in which nuclear radiations interact with matter to provide energy which can be detected, and the use of this energy for detection, are covered in detail. The basic physics of detectors are also given in detail, and the design of detectors is discussed. A final chapter covers the applications of detectors for specific radiation. A bibliography is included. (J. Sharpe. London, Temple, 1960. 71 p., 12/6.)

NUCLEAR REACTOR OPTIMIZATION.

Most reactor types have ten or more independent variables, but only one combination of values will produce electricity at the lowest cost. This monograph describes the systematic methods which must be used to achieve this optimization of the reactor, and illustrates by giving a complete worked example on the design and optimization of a nuclear station. (P. H. Morgen. London, Temple, 1960. 81 p., 12/6.)

KEMPE'S ENGINEERS YEAR-BOOK, 65TH ED., 1960.

Once again, the Year-book has been extensively revised, and new sections included on electronic engineering, nuclear power, prestressed concrete, diesel locomotives and railcars, railway brakes, railways signalling and naval architecture. Various shorter additions have been made, and reference is made to new and revised British Standards. Brief bibliographies are included, and the detailed index contains over 100 pages.

The Year-book is written by specialists, and its volumes are invaluable to any engineer. (Ed. by C. E. Prockter. London, Morgan, 1960. 2 vols., 87/6.)

*APPLICATIONS OF THERMOELECTRICITY.

An elementary account of the applications of thermoelectricity in semiconductors and the uses of the Peltier effect for refrigeration. The theory of thermoelectricity is outlined; the thermoelectric properties of semiconductors, selection of semiconductors, properties of semiconductor alloys, the preparation and evaluation of materials for conductivity, and thermoelectric generation comprise the rest of the book. (H. J. Goldsmid. Toronto, Ryerson, 1960. 118 p., $2.25. Methuen's monographs on physical subjects series.)

MATHEMATICS FOR ENGINEERS.

Volume 1, now in its 9th edition, covers the fundamental rules and processes of algebra, plane trigonometry, mensuration and graphs. There are chapters on the application of difficult curve equations, the determination of laws, and the construction of practical charts.

The 5th edition of volume two is concerned with differential and integral calculus and its applications, particu-

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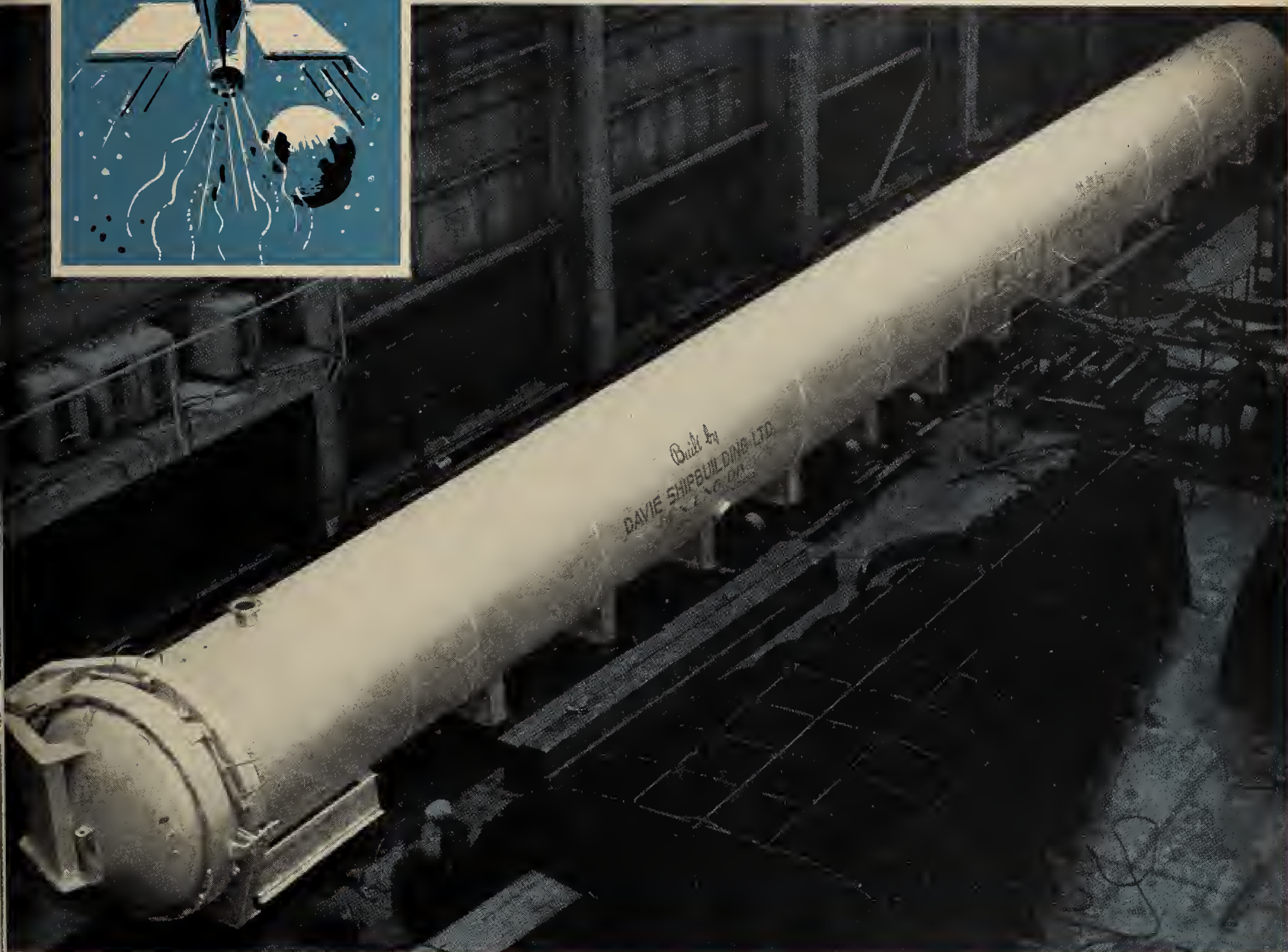

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larly in the engineering field. Chapters on spherical trigonometry and mathematical probability are also included. Worked examples and problems are included throughout both volumes. (W. N. Rose. New York, Rider, 1958. 2 vols., $6.60 per vol.)

DIRECT CURRENT ELECTRICITY.

Intended for the student and general reader, this volume discusses the fundamentals of direct current electricity in terms of the Franklinian approach, that is, plus to minus flow of current. The topics covered include electrochemistry, series and parallel circuits, electrical measuring instruments, electrical heat, and the generation of electromotive force by electromagnetic induction. (Alexander Efron. New York, Rider, 1960. 91 p., $2.25.)

UNDERSTANDING MICROWAVES.

A discussion of the fundamentals of microwaves, their generation, transmission and application. It includes an explanation of electromagnetic and electrostatic fields, radiation and reflection, Poynting's vector and Maxwell's equations, wave guides, coaxial lines, resonant cavities, and antennas.

This is an abridged reprint from which are omitted the sections on the elaboration of microwave terms, ideas and theorems. (V. J. Yound, New York, Rider, 1960. 292 p., $3.50.)

*FOUNDATION DESIGN AND PRACTICE.

Economy in the design and building of foundations is stressed. Beginning with the choice of site and a consideration of the demands of the superstructure, the author then describes various foundation types and how they are installed. He continues with laboratory and field testing of soil and foundation units, specifications and contracts, and building codes. A basic design procedure is proposed and described in the concluding section. The efficiency of this procedure is based in large part on the frequent use of battered pile and caissons and tension units. (J. N. Thornley. New York, Columbia University, 1959. 296 p., $15.00.)

RIVER STUDIES.

A report prepared for the Government of Nigeria by NEDECO (Netherlands Engineering Consultants) on the conditions in the 3000-mile long Niger and Benue River systems, with the object of determining how navigation could be improved.

The investigation lasted three years, and covered many aspects of the river system. The first part of the report gives a summary of the studies, a description of the rivers, information on present navigability, etc. In Part II a detailed description of the actual investigation is given, including planning, staff and equipment, measurements taken. Part III deals with the rivers, explaining their hydrological and morphological regime, and describing their other characteristics. Part IV includes information on transport in general, the rivers as navigable waterways, and navigation and shipping in Nigeria. Part V summarizes the defects of navigability.

The final section, Part VI contains the consultants' recommendations for improving navigability.

This is a well-written, well-printed report, containing innumerable illustrations, charts and diagrams, together with a bibliography. It necessarily includes much information on Nigeria in addition to that on the river system. The sections on the characteristics of the rivers, and possible river-engineering works are sufficiently detailed to be used as a textbook for the Nigeria Inland Waterways Department. (NEDECO. Amsterdam, North-Holland, 1959. 1000 p., £7.)

*HYDROMAGNETIC CHANNEL FLOWS.

This book presents analyses for three flows of viscous, incompressible, electrically conducting fluids in high-aspect-ration rectangular channels subjected to transverse magnetic fields, using methods based on hydro-magnetic equations, dimensional analysis, and experiment. Principal results of this study include a scheme for correlating experimental friction-factor data and methods for computing mean-velocity profiles, mean magnetic-field distortion, current distributions and turbulent-shear distributions in the d-c turbulent flow. (L. P. Harris. New York, Wiley, 1960. 90 p., $2.75.)

SURVEY OF OILS, 1960.

The basic reference book on the Canadian oil and gas industry contains all the information needed by the investor. Reviews of active and inactive Canadian companies occupy most of the book giving data on property acreages and locations, production, finances, officers, etc. Also included are maps of oil and gas fields, lists of producing fields, production reserves, price range of stocks, etc. (Financial Post. Toronto, Maclean-Hunter, 1960. 248 p., $4.00.)

COLOUR IN INDUSTRY TODAY.

Concerned with the functional use of colour, the author in this volume explains in detail the theory of colour psychology. He shows the many benefits which can accrue from carefully planned colour schemes, and gives examples from his own experience in factories, offices, schools and hospitals. The relationship between colour and light is also discussed. Coloured plates illustrate the points made in the text. The author was a leading colour consultant, and Art Director of the British Colour Council for 25 years. (R. F. Wilson. London, Allen and Upwin, 1960. 90 p., 35/-.)

SHORTHAND FOR THE MIND.

Always remember the face but never the name? Forget your own telephone number? The five lessons in memory training in this book will show how you can remember hundreds of names, telephone numbers, addresses, statistics, etc. As the shorthand writer uses written symbols, so Mr. Wermont's method uses mental symbols to make remembering almost automatic.

This is an interesting book. (I. Wermont. Dorchester, Mass., the Author, 1955. 64 p.)

*TORSION DEVICES.

This book reviews the design, construction, and application in instruments of torsion devices used as frictionless suspensions for the moving parts of sensitive instruments, as hinges for levers and the like, and for the magnification of small displacements and the indication of small forces. Included are a forty-page annotated bibliography and a numerical index to British, French, German, Swiss, Swedish and American patents. Part No. 5 in the B.S.I.R.A. Survey of Instrument Parts. (P. J. Geary, Chiselhurst, Kent, England, 1960. 142 p., 23/6.)

AMERICAN BUILDING ART: THE NINETEENTH CENTURY.

The nineteenth was a century of great changes in building construction, which became a science rather than an art. The coming of the railroad had a great effect on the number and types of structures to be built, and the author deals with the wooden bridge truss, the iron bridge truss, the suspension bridge, the iron arch bridge, and the railway trainshed. He also covers wood and iron framing, and concrete construction. Many illustrations and a useful bibliography are included. The author has also written the Rise of the Skyscraper, a study of the Chicago school of architecture. (C. W. Condit. Toronto, Oxford, 1960. 371 p., $12.50.)

THEORIES OF SCIENTIFIC METHOD: THE RENAISSANCE THROUGH THE NINETEENTH CENTURY.

Thirteen studies of the philosophy of science, as expressed by some of the leading thinkers over a period of five centuries. The topics and problems with which these writers were primarily concerned were: theory construction; hypothesis; casuality; lawfulness; probability; the problem of induction; the universality of casuality; the problem of discriminating the a priori and the empirical elements of science. Ideas of many philosophers are discussed, and quotations from their writings given, and particular attention is paid to Bacon, Descartes, Hobbes, Newton, Hume, Herschel, Whewell, Mill, Jevons, Peirce and Wright.

This should prove a useful reference tool, as well as being interesting reading. (Ed. by E. H. Madden. Seattle, Univ. of Washington Press, 1960. 346 p., $6.50.)

CHARACTERISTICS OF ENGINEERS AND SCIENTISTS.

The findings of a study made to try and determine the characteristics of engineers and scientists as a group, compared to other groups of employees. The study also enquired into job activities

(continued on page 138)

Improve product performance, cut costs with 3M Adhesives, Coatings and Sealers

VIBRATION RESISTANT. Tough aluminum strips (bonded in the middle, above) tear before 3M Brand EC-801 bond separates! This versatile sealer is especially suited for integral fuel tanks, keeps them tightly sealed in spite of vibration and flexing. Highly resistant to aircraft fuels; adheres firmly to metals at temperatures from −65°F. to 180°F.

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CORROSION RESISTANT. Rugged torture test! 2000 hours exposure to salt spray; 20 weeks submersion in 20% solution of hydrochloric acid; six-month weather exposure in Miami, Florida proved CORO-GARD* 1706 Brand Protective Coating resists abrasion and corrosion. For steel, aluminum, wood, concrete, cloth and some plastics.

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(continued from page 134)

and satisfaction, and the problems facing young professionals.

It is a qualitative study, and is based on some four hundred interviews conducted in ten companies. It summarizes and discusses the results of the interviews, and provides a series of recommendations for management for using the data, and for young engineers and scientists. (L. E. Danielson. Ann Arbor, Univ. of Michigan, Bureau of Industrial Relations, 1960. 136 p., $4.00.)

MECHANICS OF MATERIALS.

Designed for a first course in mathematics, this volume puts its emphasis on the elastic range of stress. It presents the fundamental principles, and shows how these are applied to develop logical methods of procedure. The subjects covered include centric, torsional and flexural loading; statically indeterminate beams; combined loading; columns;; repeated and dynamic loading; connections. Problems are included. (A. Higdon, E. H. Olsen and W. B. Stiles. New York, Wiley, 1960. 502 p., $7.75.)

*BERYLLIUM.

A collection of present information on beryllium, giving its properties in detail, a summary of the different fabrication and extraction routes for the metal, and special attention to such increasingly important uses of beryllium as in aircraft, missiles, and nuclear reactors; as an alloy base or additive; and in the preparation and use of the oxide beryllia. In cases where results are contradictory in this rapidly developing field, the fullest amount of experimental details are given. (G. E. Darwin and J. H. Buddery. Toronto, Butterworth, 1960. 392 p., $13.50.)

CONCRETE FORMWORK DESIGNER'S HANDBOOK.

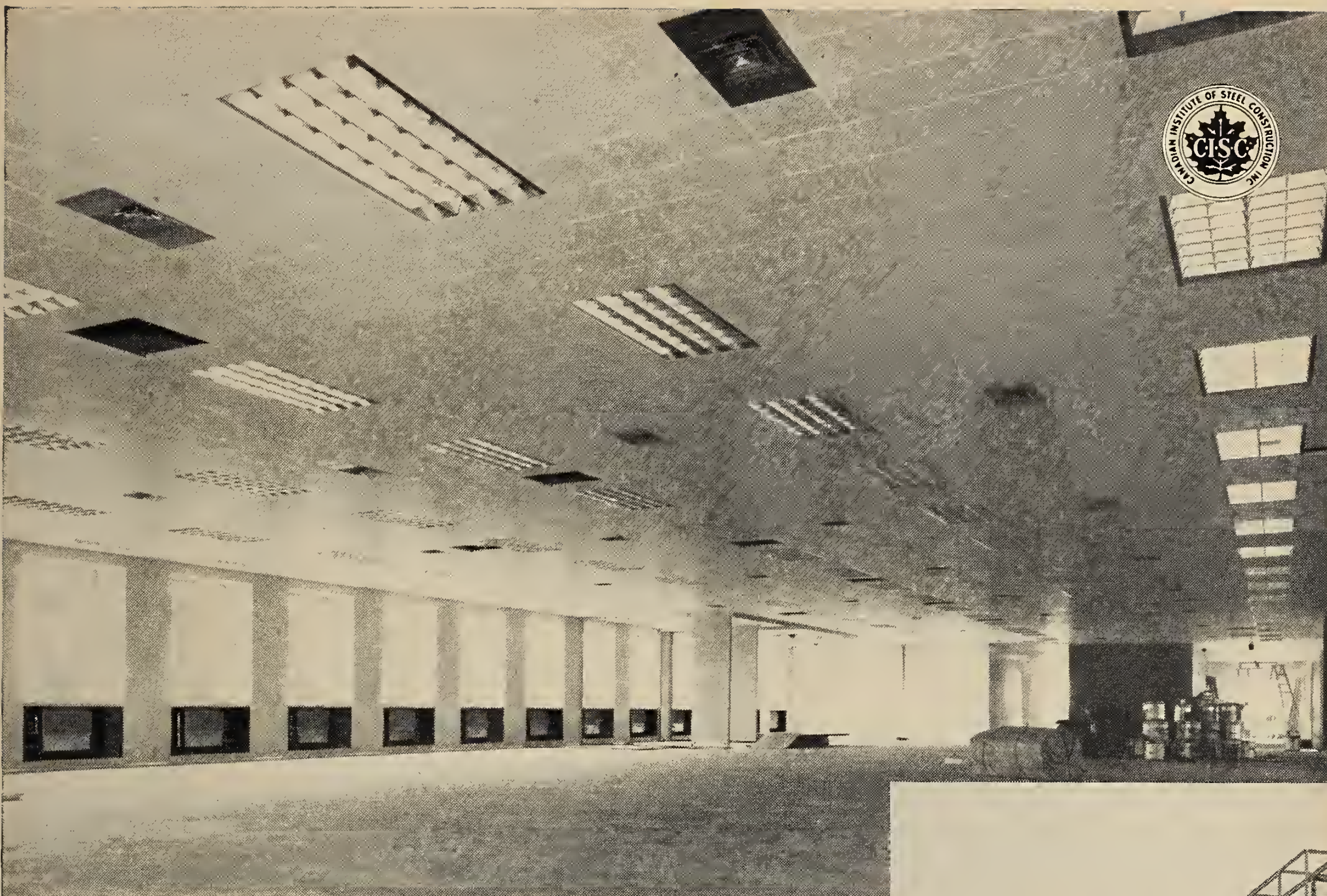
Concerned with the structural design of formwork in timber and steel, this handbook includes over fifty nomograms, tables and charts for the rapid design of formwork for various types of construction. The factors affecting the pressure of concrete against the forms are discussed, as are permissible stresses in the formwork materials. Several worked examples explain the use of the nomograms, charts, etc., and a brief bibliography is included. (H. R. Gill. London, Concrete Publications, 1960. 153 p., $3.50.)

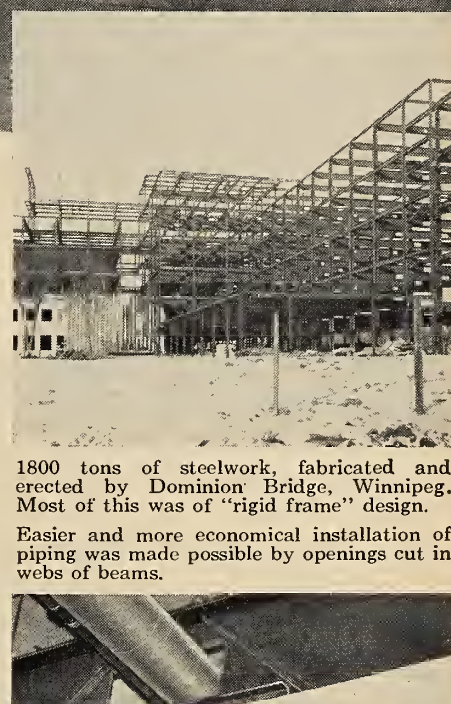
BASIC ULTRASONICS.

A simple introduction, in the Rider "pictured text" series, to the subject of ultrasonics. The first section of the book covers the general theory of ultrasonics, particularly the nature of sound and ultrasound waves. The second section describes the basic types of ultrasonic equipment, and the third discusses applications, including sonar, nondestructive testing, cleaning, welding, cameras, instrumentation, and biological and chemical effects. (Cyrus Glickstein. New York, Rider, 1960. 137 p., $3.50.)

TEXTBOOK OF METALLURGY, 2ND ED.

In this second edition, many sections have been re-written, in particular those on crystallization, plastic deformation and the benefication of iron ores. Information has been added on the metallography of radio-active metals, zone-re-





fining, blast-furnace production of zinc and the extraction of titanium and uranium.

The book covers the nature, structure and properties of metals and alloys; the examination of metallic structures; the theoretical and practical aspects of metal production; the production of ingots and castings; metal working; metal testing. Problems and suggestions for further reading are included. (A. R. Bailey. Toronto, Macmillan, 1960. 561 p., $5.00.)

RADIO CONTROL FOR MODEL BUILDERS.

Intended for those whose hobby is model building, and who are interested in learning how they can use radio-control, this volume tries to give an overall picture of the subject of remote control. It explains the control systems available, and discusses transmitters, receivers, actuators, installation, batteries, meters, relays, etc. It covers particularly radio-controlled planes and boats. (William Winter. New York, Rider, 1960. 220 p., $4.25.)

CHEMISTRY FOR ENGINEERS.

An introductory course, intended both for students and those needing a "refresher," some previous knowledge of chemistry being assumed. The two main themes in the text are the chemistry of power production and chemistry of materials. The ten chapters cover nuclear chemistry; atoms and molecules; chemical reactions; chemical fuels; metals; acids and bases; corrosion; water treatment; plastics; friction and lubrication. (Edward Cartmell. Toronto, Butterworths, 1959. 172 p., $5.00.)

PRINCIPALS OF CHEMICAL THERMODYNAMICS.

Intended for an introductory thermodynamics course at the graduate level, the text stresses the principles of thermodynamics, in a logical and critical manner, and shows their application to chemistry. The topics covered include conditions of equilibrium and the free energy functions; gases and vapors; thermochemistry; statistical thermodynamics; mixtures and solutions; chemical and phase equilibria; electrolytic solutions and electro-chemical cells; thermodynamics of surfaces; systematic methods of deriving thermodynamic relations. (C. E. Reid. New York, Reinhold, 1960. 306 p., $7.80.)

CANADIAN TRADE INDEX, 1960.

A directory of products manufactured in Canada, listed under some 10,000 headings and an alphabetical listing of more than 11,000 Canadian manufacturers. There is a French index to the headings used in the classified section. Many new firms and products are included in this edition of the Index, which is an essential volume for anyone concerned with purchasing. (Toronto, Canadian Manufacturers Assoc., 1960. 1150 p., $12.50.)

***THE DYNAMIC BEHAVIOR OF THERMOELECTRIC DEVICES.**

This is the report of a study of the dynamic behaviour of thermoelectric heat pumps and generators, made by means of a small-signal analysis of linear models. This analysis produces small-signal transfer functions that can be used to compute the response of devices in the frequency domain or in the time domain. Here, the small-signal analysis for the heat pump and for the thermoelectric generator and measurement of the small-signal response of a heat pump are described. There is also a chapter examining the modification of the heat-pump analysis to include a temperature-dependent resistivity. (P. E. Gray. New York, Wiley, 1960. 136 p., $3.50.)

***SPECTROCHEMICAL ABSTRACTS, VOL. VI, 1954-1955.**

The 460 abstracts in the current issue of this biennial publication are arranged for the first time by subject rather than by author. Abstracts cover methods of analysis of mineral, metal, gaseous, liquid, and biological substances, the apparatus and techniques, and a few reviews of books, bibliographies, and charts. (E. H. S. Van Someren and F. Lachman, London, Hilger & Watts, 1960. 100 p., 25/-.)

***AERO-THERMODYNAMICS AND FLOW IN TURBOMACHINES.**

In Part 1 the fundamental relations for the analysis of arbitrary flows are derived from the general principles of fluid mechanics and thermodynamics applicable to the flow of any compressible media. This derivation employs vector and dyadic analysis, the elements of which are summarized in appendices A and B. Part 2 treats flows which are idealized either with respect to the properties of the fluids or the thermodynamics process they undergo. Part 3 discusses flows in turbomachines wherein the concepts of Parts 1 and 2 are affected by the primary function of turbomachines, which is to change the energy level of fluids, and because the members guiding the flow in turbomachines are surfaces of revolution. (M. H. Vavra. New York, Wiley, 1960. 609 p., $14.50.)

***SCHUTZE UND SCHUTZENSTEUERUNGEN.**

A treatise on contactors, covering basic principles, behavior under abnormal conditions, and the great variety of control devices and protective equipment utilizing contactors. Separate chapters are devoted to special types, durability, selection criteria, control methods, signal equipment, and test methods. There is an extensive bibliography including a scattering of English references. (Herbert Franken. Berlin, Springer-Verlag, 1959. 382 p., DM 42.00.)

***SEMICONDUCTOR ABSTRACTS, Volume V-1957 issue.**

Some 1700 references are listed in the new volume of this useful and thorough compilation. Most of the entries are from 1957 with a scattering of earlier ones from a few foreign journals. Through

1951 Graduates – Please Note

According to amended Institute regulations covering Junior membership, 1951 graduates must apply for transfer (by written application form) to the grade of Member during 1960, if they wish to avoid payment of a transfer fee.

The applicable sections are as follows:—

"———— he shall not remain in the class of Junior beyond the end of the tenth year after graduation.

A Junior may be transferred to Member without payment of a transfer fee providing he makes application before the end of the ninth year after graduation ————"

intensive editing, more cross-references, reduction of duplication, and elimination of phenomena of lesser relevance like organic ferroelectrics and solution luminescence, this edition of the abstracts is smaller and the coverage more intensive than previous ones. Arrangement is by subject with four main divisions: elemental semiconductors; compound semiconductors; theory; and general applications. (Ed. by G. S. Peet. New York, Wiley, 1960. 449 p., $12.00.)

STANDARDS RECEIVED

Aluminum Association standards.
The Aluminum Association,
420 Lexington Ave., New York 17, N.Y.

Supplement to drafting standards—aluminum extruded and tubular products. 3d ed. 1960.

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

B149—1958, Suppl. no. 1—1960—Installation code for gas-burning appliances and equipment. 25c.

C22.2 no. 12—1960.—Construction and test of electric portable lighting devices. 3d ed. $1.00.

C22.2 no. 28—1960—Construction and test of all-asbestos, asbestos-varnished-cloth, and asbestos-thermoplastic insulated wires and cables. 2d ed. $3.00.

C22.2 no. 49—1960—Construction and test of flexible cords and fixture wires. 4th ed. $4.50.

C104.1—1960—Specification for lineman's body belt and lineman's safety strap. $1.50.

O15.3—1960—Specifications for the physical properties of jack, lodgepole, and red pine poles, and reinforcing stubs. 3d ed. $1.50.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Aerodynamics.
Theoretische und experimentelle Untersuchungen an Querstromgebläsen, by Robert Coester, Zurich, Verlag Leemann, 1959. 57p., 14 Sw. Fr.

Aviation. Space travel.
High altitude chambers and pressure suits and their part in manned flight to the moon, by E. W. Still. Yeovil, Eng., Normalair Ltd., 1960. 40p.

Bridges. Steel.
Prize bridge 1958. N.Y., American Institute of Steel Construction. 11p.

Canada. Dept. of Mines and Technical Surveys.
Geographical Branch.
Bibliographical series.
Bibliography of periodical literature on Canadian geography 1930 to 1955; part 6, Northern Canada. Ottawa, 1959, 36p. (No. 22). 50c. Selected bibiliography on periglacial phenomena in Canada; annotations and abstracts, by F. A. Cook. Ottawa, 1960. 22p. (No. 24). 50c.

Geographical papers.
Gulf of St. Lawrence ice survey, winter, 1959, by W. A. Black. Ottawa, 1960. 41p., (No. 23). 75c.

Dynamique et caractéristiques des glaces de dérive de l'estuaire et de la partie nord-est du golfe Saint-Laurent, hiver 1957-1958, par Michel Brochu. Ottawa, 1960. 93p. (No. 24). $1.00

Memoirs.
A photo-reconnaissance survey of Labrador-Ungava, by F. K. Hare. Ottawa, 1959. 83p. (No. 6). $2.00.

Canada. Dept. of Mines and Technical Surveys.
Mineral Resources Division.
Mineral information bulletins.
Survey of the copper industry in Canada 1958, by A. F. Killin. Ottawa, 1960. 108p. (MR37). 50c.
Some economic factors affecting northern mineral development in Canada, by Amil Dubnie. Ottawa, 1960. 61p. (MR 38). 50c.
Operators lists.
Metal and industrial mineral mines in Canada. Ottawa, 1960. 27p. (List 2). 25c.
Milling plants in Canada; metallic ores. Ottawa, 1959. 49p. (List 3, pt. 1). 25c.
Milling plants in Canada; industrial minerals. Ottawa, 1960. 43p. (List 3, pt. 2). 25c.

Canada. Dept. of Mines and Technical Surveys.
Surveys and Mapping Branch.
Pilot of Arctic Canada. vol. 1. Ottawa, 1959. 183p. $5.00.

Canada. National Research Council.
Aeronautical reports.
Brief experiments on a flapped aerofoil having a cusped cavity and a blowing jet at the cusp, by A. D. Wood. Ottawa, 1959. 10p. (LR 269) Turbojet thrust augmentation: flight measurements of the turbine blade cooling accompanying the preturbine injection of reheat fuel with an Orenda 14 engine in a Sabre 6 aircraft, by E. P. Cockshutt, G. G. Levy and C. R. Sharp. Ottawa, 1960. 10p. (LR 271).
A technique for producing glass-reinforced foam-filled plastic model propeller blades, by A. J. Bowker and L. A. J. Pelland. Ottawa, 1960. 10p. (LR 273).

Canada. National Research Council.
Division of Building Research.
Pile construction in permafrost, by J. A. Pihlainen. Ottawa, 1960. 21p. (Technical paper no. 90). 25c.

Concrete. Reinforced.
Elementary analysis of hyperbolic paraboloid shells. Chicago, Portland Cement Association, 1960. 23p. (Reinforced concrete 35).

Electric Circuits.
Tensors for circuits, by Gabriel Kron. 2d ed. N.Y., Dover, 1959. 250p. $1.85.

Electric Power Supply. France.
Electricité de France, 1946-1958. Paris, Editions A. & P. Jarach, 1959. 173p.

Electrical engineering.
Electrical Research Association.
Technical reports.
Intrinsically safe electrical apparatus, by E. R. Wooding and F. Shaw. 1958. 7p. (D/T106). 6/—.
The spontaneous ignition temperatures of inflammable gases and vapours, by H. G. Riddlestone. 1958. 16p. (D/T110). 10/6d.
Switching transients measured on the live 132 kV system, by J. S. Vosper. 1959. 17p. (G/T319). 15/—.
The resistance of sheet insulation to surface discharges, by J. H. Mason. 1958. 15p. (L/T379). 15/—.
The protection of 11 kV and 33 kV line insulators from damage by power arcs, by A. E. Guile and S. F. Mehta. 1958. 12p. (O/T23). 12/—.
Joints in aluminum and aluminum alloy busbars, by A. P. Singh. 1959. 16p. (Z/T118). 12/6p.
The electrical year book, 1960. Manchester, Emmott, 1960. 361p. 4/—.
Phénomènes non linéaires et paramétriques en électroniques, par A. A. Kharkevitch, Paris, Dunod, 1960. 224p., 16.50 N.Fr.

Engineering.
Engineering reprints, nos. 1-31, 1953-58. University of Western Australia, School of Engineering. Nedlands, Western Australia, 1959. 30p.

Heat transmission.
The theory of heat radiation, by Max Planck. N.Y., Dover, 1959. 224p. $1.50.

Instruments.
British instruments; directory and buyers' guide, 1960. Lond., Scientific Instrument Manufacturers' Association, 1960. 635p., £2.5.

Joints.
Corner connections loaded in tension, by J. W. Fisher and G. C. Driscoll. Bethlehem, Pa., Lehigh University, 1959. 10p.
Fatigue and static strength of stud shear connectors, by Bruno Thurlimann. Bethlehem, Pa., Lehigh University, 1959. 16p.
Welded interior beam-to-column connections, by J. D. Graham, A. N. Sherbourne, and R. N. Khabbaz. N.Y., American Institute of Steel Construction, 1959.

Materials handling.
Appareils de levage et de manutention. 2 v. La Technique Moderne, numeros spéciaux, juillet 1959 et février 1960.

Mechanical engineering.
Mechanical world year book, 1960. Manchester, Emmott, 1960. 362p. 5/—.

Mechanics.
Vocabulary of classical mechanics in 5 languages; Polish, German, English, French, Russian. Warsaw, Panstwowe Wydawnictwa Techniczne, 1959. 75p.

Metals and alloys.
Metal industry handbook and directory 1960. Toronto, British Book, 1960. $5.25.

Microwave transmission.
Microwave transmission, by J. C. Slater. N.Y., Dover, 1959. 309p. $1.50.

Mines and mining drainage.
Acid mine drainage manual, by R. A. Brant and E. Q. Moulton. Columbus, Ohio State University, 1960. 40p. $1.00.

Nuclear energy.
Introduction to atomic energy, by W. G. Atkinson. N.Y., Rider, 1959. 68p. $1.35.

Nuclear reactions.
Project Sherwood—the U.S. program in controlled fusion, by A. S. Bishop. Toronto, Doubleday, 1960. 227p. $1.45.

Probability.
Introduction à la théorie des probabilitiés, par B. V. Gnédenko et A. la. Khintchine. Paris, Dunod, 1960. 157p., 12.50 N.Fr.

Quantum mechanics.
Principles of quantum mechanics, by W. V. Houston. N.Y., Dover, 1959. 288p. $1.85.

Railroad tracks.
Stabilizing railroad track by pressure grouting. Chicago, Portland Cement Association, 1960. 8p.

Refractories.
Harnessing the fires of industry. Montreal, Canadian Refractories Ltd., 1959. 31p.

Roads and streets.
Experimental continuously-reinforced concrete pavements: progress reports, 1959. 104p. (U.S. Highway Research Board, Bulletin 238). $2.00.

Sound.
Waves and the ear, by W. A. Van Bergeijk, J. R. Pierce and E. E. David, Jr. Toronto, Doubleday, 1960. 235p. $1.10.

Steel.
Commentary on plastic design in steel; progress reports nos. 1-4. Bethlehem, Pa., Lehigh University, 1959. 2v.

Structural design.
Plastic design of pinned-base "lean-to" frames, by R. L. Ketter and Bung-Tseng Yen. N.Y., Welding Research Council, 1959. 20p., $1.00.

Television.
The physics of television, by D. G. Fink and D. M. Lutyens. Toronto, Doubleday, 1960. 160p. $1.10.

Time.
Rider global time conversion simplifier. New York, Rider, 1960. 1p. $1.00.

Transistor circuits.
Introduction aux circuits à transistors, par E. H. Cooke-Yarborough. Paris, Dunod, 1960. 161p., 14 N.Fr.

Business and Industrial Briefs

Appointments and Transfers

MANAGEMENT SERVICES is a new department at C.I.L. It will consist of existing staff functions under one jurisdiction and will maintain a staff trained in industrial engineering, operations research, office systems and procedures, statistics, and other management skills. The manager will be **M. S. Macgillivray**, formerly head of engineering services.

Joseph Gilbert has been named SECRETARY AND GENERAL MANAGER of the Society of Automotive Engineers (SAE). He has served in the Society's Publication Division as managing editor of the SAE Journal and for the past three years has been assistant general manager of SAE, which has more than 24,000 members among engineers engaged in the design, development and manufacture of motor vehicles, farm tractors, earthmoving machinery, aircraft and space vehicles.

John B. Jolley, native of Hamilton and graduate of McMaster and Osgoode Hall Law School, is MANAGER OF PERSONNEL for B. F. Goodrich Canada Limited. His new assignment will include both manufacturing and salaried employee relations activities.

Sika Chemical Canada Limited announces the appointment of **W. E. (Bill) Murray** as Western Ontario DISTRICT SALES MANAGER.

Joseph E. Wolfe becomes INDUSTRIAL PRODUCTS REPRESENTATIVE at Sun Oil. Mr. Wolfe is a mining engineer B.A.Sc. and former instructor at the University of Toronto.

Robert W. Reinicke, a mechanical engineering graduate of Ohio State, has been named VICE-PRESIDENT OF OPERATIONS at Ansul Chemical Company, Marinette, Wisconsin.

New Developments

POSITIVE SHUTOFF and freedom from galling are the features of a new "floating cone" ¼ in. hand valve announced by The Foxboro Company, Massachusetts. Recommended for liquid or gas service on meter manifolds, seal chambers, hydraulic equipment and similar applications, the new valve is supplied in five variations of globe and angle types, accommodating line pressures up to 3000 p.s.i.

THE CUTTING HEAD is replaceable on a new masonry core drill announced by Canadian General Electric's Carboloy Section. One drill body and separate cutting heads will do the work of several complete drills, reducing delays and inventory costs. Heads are easily attached or removed and the drills can be had in standard sizes from 1⅜ in. to 6 in. diameter for use on cement and cinder block, plaster, brick, tile, slate, marble, stone, concrete, even reinforced concrete.

EARNINGS WERE UP in the first half of 1960 according to a statement issued by Shawinigan. Consolidated earnings of Shawinigan Water and Power, St. Maurice Power and Southern Canada Power amounted to 80.07 cents per common share, compared with 70.80 cents for the first half of 1959.

THE LARGEST manganese steel mantle ever cast in Canada was poured on May 21 in Joliette, Quebec for a 689 Superior gyratory crusher. Canadian Allis-Chalmers is building the machine for the Iron Ore Company of Canada's Carol Lake project. Largest crusher to be made in Canada, it will rise more than 30 ft. and weigh 400 tons. The mantle itself weighed over 23,000 lb. Overall measurements were about 12 ft. high by 7 ft. 5 in. in diameter.

PLEASURE BOATING has been revolutionized by the Dowty Turbocraft, which in tests has taken rapids, marsh lands, sandbars and even a neck of dry land in its stride. Weeds are chopped up and churned out. The boat's jet unit sucks in water through a grille in the bottom of the hull and ejects it above the water line through a nozzle in the transom. The reaction to the outgoing jet stream provides the forward thrust. Deflecting the jet stream by means of hinged plates steers the boat to right or left, and lowering a metal gate deflects the jet forward to reverse the boat.

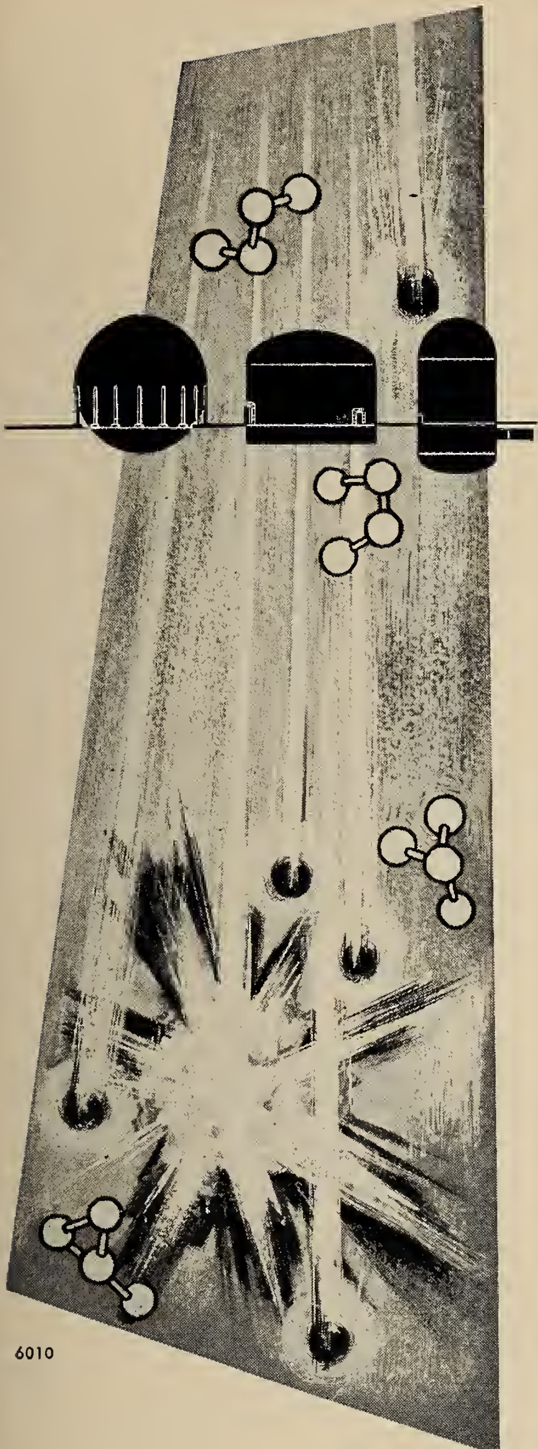
LIGHTWEIGHT CONCRETE as a strong, durable structural material for columns, beams and floor slabs, multi-story structures, and bridge decks is featured in a new Master Builders Company publication. Thirteen construction projects are discussed with the aid of photographs and job reports.

THE COMPACTRON is a new electronic device that combines into one unit the functions now performed by several components and will enable manufacturers to reduce the size of radios, television, high-fidelity sets and electronic organs. Canadian General Electric recently displayed a two-compactron radio which was 2½ in. high, 2½ in. deep and 10½ in. wide—the width being dictated by the generous size of the speaker. Underlying metallurgical developments include a new anode material that reduces heater power requirements of the cathode and a clad material that improves the hot strength and thermal efficiency of cathode elements.

ALUMINUM CAN take the stresses and shocks of mining operations. Two aluminum off-highway dump bodies which are mounted on the largest single rear axle chassis in the world have been ordered by Canadian Johns-Manville. When tests were made last summer, rocks weighing up to 6 tons were dumped into aluminum units from 10 ft. heights over a two-day period.

18,000,000 GALLONS DAILY is the volume handled by Fairbanks-Morse Pumping Equipment installed at Cornwall's new filtration and water purification plant. A Model 5813 high lift pump supplies the volume against a total dynamic head of 190 ft. It is driven by an F-M type QZK–400 hp. motor. Two other Model 5813 high lift pumps provide 5,000,000 IMP/GPD each against a total dynamic head of 180 ft. They are powered by F-M type QZK–250 hp. motors.

FORD HAS been able to produce tractor linkage bars at a lower cost and feature furthermore increase output by using a British Oxygen Bison profile cutting machine at Imperial Foundry in England. The machine cuts the steel bars to length with extremely fine tolerances for final flash-butt welding. In addition, there is a longitudinal cutting operation



6010

NUCLEAR POWER NEEDS LOOKING AFTER . . .

Horton knows how!

Nuclear power, mighty power source of the future, needs looking after. Nuclear Reactors have to be thoroughly protected to avoid radio-active contamination of people and property. Constructing special steel plate Reactor Containment Vessels requires great skill and vast engineering experience. Horton has the skill and engineering background to erect these special vessels because they have been fabricating and erecting all types of quality steel plate structures throughout Canada for many years. Horton will be pleased to supply you with further information on request.

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Plants and Offices throughout Canada

TANKS AND STEEL PLATE WORK FOR MUNICIPALITIES, PETROLEUM AND OIL, CHEMICAL PROCESS, MINING, PULP AND PAPER, AIRCRAFT . . . AND INDUSTRY AT LARGE.

on the bars, this being a straightforward profiling process.

DEAD ENDS are stronger if forged. This component of a compression assembly used with high tension electrical lines must provide strength and dependable service over long periods. Stelco drop-forges these parts by modern techniques and produces complicated shapes to close tolerances.

TUNNEL SHIELDS for use in the construction of Toronto's new subway are nearing completion at the Trois Rivieres plant of Canada Iron Foundries. The six massive shields are the first to be designed and built in this country. Four of the shields, weighing 70 tons each, are for the running tunnels and two larger shields of about 130 tons are for tunneling two subway stations.

LIVE CARGO presents many problems to trucking companies. Shifting loadweight can cause uneconomic conditions when payload is reduced to prevent excess maintenance and repairs, and transports used for cattle are not readily adaptable to dry freight. A new series of pusher-tandem diesels, developed by the White Motor Company, will haul the first tri-level livestock unit built by the Freuhauf Trailer Company. The trailer provides for control of weight distribution and will hold an average of 40 head of cattle based on an approximate weight of 1000 lb. per animal. This compares with 27 cattle previously carried in trailers.

ZOOMING SALES of Mimik hydraulic machine tool tracer attachments in the U.S.A. have led Retor Developments Limited, a wholly Canadian owned company with head office and plant at Galt, Ont., to incorporate an American subsidiary which will be located at Buffalo, N.Y. The Mimik is a high precision hydraulically operated tracer which can be attached to any standard machine tool.

AIR CONDITIONING and refrigeration are the principal concerns of the Frick Company, which has established a Canadian subsidiary, Frick of Canada Limited, Montreal.

FOR SITE WORK in oil fields and on construction projects, Chamberlain Industries of London, England have introduced a completely new type of bender in their extensive range of "Staffa" tube and pipe bending machines. The "Field" bender has been especially designed as a lightweight two-stage hydraulic unit and is supplied in two sizes, one with a range of formers for bending pipe from 2 in. to 4 in. bore and the other for bending pipe from 4 in. to 8 in. bore.

POCKET MAGNIFIERS with built-in graticules are now on the market. A model that folds into a neat unit measuring only 2⅛ in. by 1 7/16 in. by 9/16 in. has been designed to permit more precise measurement with a highly portable instrument. The micrometer, which is on glass, is mounted in the base of a low-powered folding magnifier, the whole frame being made of aluminum cut away to give maximum visibility on a field of view 1 in. square.

THE ONLY TOOL needed to make a perfect connection every time with "RED-E" lugs and splicers to welding and power cables is a hammer. Bernard Welding of Chicago introduced these lugs and splicers which eliminate special crimping tools, wrenches, and soldering equipment.

CORRECT EXPOSURE in aerial photography is easier with Kodak's two-dial computer. The Kodak Aerial Exposure Computer has just been published in the form of a six-page folder which contains the computing dials, instructions for their use, a typical aerial exposure problem and its solution with the computer, and tables which give the altitude of the sun above the horizon in degrees for any point in the world at any time.

A DISTRIBUTING PLANT has just been opened in the London, Ontario area by the St. Lawrence Cement Company. The aerated storage silo and warehouse will supply high quality cement in bulk and bag. The company

E.I.C. CERTIFICATE OF ADVERTISING MERIT — WINNING ADVERTISEMENT

For the fourth time in a twelve month period, a Honeywell Controls Limited advertisement has been judged the "best" in an issue of The Engineering Journal by a fifty reader jury.

Tabulations of the jurors' appraisals of the advertising in the June 1960 issue —from the viewpoints of ACCURACY— INFORMATION and ATTRACTION— showed votes very much in favour of the 4-page, 3-color Honeywell Controls Limited insert headed: "MODULAR DESIGN MAKES 1960 ELECTRONIK POTENTIOMETERS A GREATER VALUE THAN EVER".

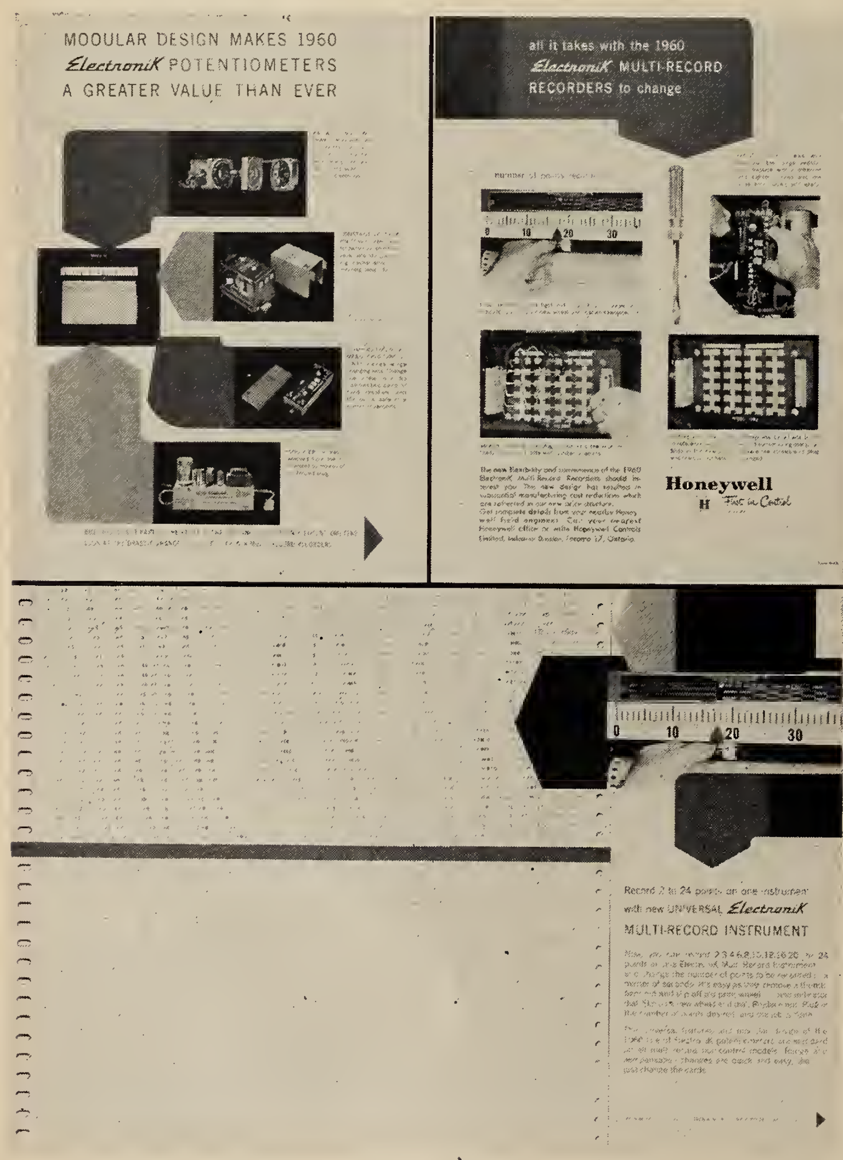
The judicious use of color, pleasing layout and concise, informative copy, coupled with descriptive illustrations, are features of this insert as was the case in previous Honeywell Controls Limited winning advertisements.

K. K. Warne, of Toronto, is in charge of the company's Canadian advertising arrangements and the advertisement was prepared and placed by the Toronto office of Cockfield, Brown & Co. Ltd.— A. D. Black—Account Executive.

HONEYWELL CONTROLS LIMITED WINS CERTIFICATE

This reduced-scale, monotone, reproduction of the 4-page, 3-color Honeywell Controls Limited insert in the June 1960 issue does not do justice to the pleasing appearance of the original advertisement. Interested readers are advised to look at a copy of the original which appeared on pages 33-36.

FRONT BACK



CENTRE SPREAD

• MORE BRIEFS

has recently acquired another quarry near Colborne, Ontario which will provide aggregates for their Clarkson manufacturing plant.

A PLASTIC SECTOR which replaces the traditional wooden sector and offers advantages both in durability and in less frequent shutting down for maintenance is now being produced by the Mechanical Goods Division of Dominion Rubber Company Limited. It is available for 6 ft. diameter fillers and will soon be available for larger sizes. Smooth and non-splintering, it is non-porous, and will neither warp nor swell.

RANGE AND FLEXIBILITY for all types of noise measurement have been increased in the new soundscope produced by Mine Safety Appliances Company, Toronto. Two alternate microphone systems have been incorporated in the new model — one a condenser microphone extending the sound level range up to 200 db.; the other a dynamic microphone designed for use under conditions of extreme heat or humidity. The M-S-A Soundscope provides noise survey data in three areas of interest to industrial hygienists, safety engineers and acoustic specialists.

FASTENINGS INTO BRICK, concrete, metal and wood can be accomplished with the new all-metal thread screw anchor produced by Rawlplug Products (Canada) Limited, Montreal. Designed for 3/16 in. screws, the manufacturers claim the "Rawlset" can easily support 150 lbs. in direct pull in brickwork. The tough brass shell, theaded internally to receive the screw and knurled externally to give extra grip when tightened in position, is split at one end into four sections and contains a special aluminum expander shaped so that when the screw is driven in the sections expand and grip the sides of the hole firmly.

A RETRAC BIT and coupling sleeve which can be used together or separately are being manufactured by Sandvik and distributed in Canada by Atlas Copco. The detachable bit and sleeve, particularly effective in rock where there is difficulty in withdrawing drill rods from drill holes, are designed to achieve straight, round holes even in loose rock. The retrac bit has edges which allow it to cut backwards and the sleeve has four ridges to prevent reduction of hole diameter caused by cuttings settling on the wall of the hole.

SIX THOUSAND FEET of penstock liners, valued at $1.2 million, are to be fabricated for the Coteau Creek development project of the Saskatchewan Power Commission. Sparling Tank & Mfg. Co., Toronto, a division of Products Tank Line of Canada, Ltd., will do the on-site fabricating with steel from the new Interprovincial Steel Company Ltd. mill at Regina.

(more Briefs on page 164)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● MORE BRIEFS

THE APPOINTMENT of A. C. Leslie & Co. Ltd., a Canadian steel service centre firm headquartered in Montreal, to market a new family of high strength, heat-treated steels is announced by Great Lakes Steel, Detroit-based division of National Steel Corporation. The Canadian organization will direct distribution of the new specialty steels throughout Canada.

DEARCLAD 765, a new epoxy pipe coating announced by Dearborn Chemical Company, Chicago, has a rapid curing rate, exceptional resistance to physical impact, abrasion and moisture absorption. The product retains its physical properties over the temperature range of −40°F. to +250°F.

A NEW METHOD for detecting aerial film distortions as small as one five-thousandths of an inch wide was revealed recently by a team of Kodak scientists. The technique is based on an effect known as the moire pattern, a network of wavy lines.

CONSTRUCTION WILL BEGIN in September on the first phase of a $93 million natural gas pipeline system in northeastern British Columbia. Gas Trunk Line of British Columbia Ltd. announced the pipeline, to be completed in December 1961, will deliver gas from the newly-discovered fields in the vicinity of Fort Nelson, B.C., to markets in southern B.C. and the U.S. Initial capacity of the new trunk line will be 350 million cu. ft. per day and this can be increased to 650 million cu. ft. with additional compression. It will connect with the existing Westcoast Transmission pipeline near Chetwynd, B.C.

A REMOTELY CONTROLLED DEVICE with applications in many fields where it is required to rotate a shaft with a high degree of accuracy has been developed by The Plessey Company Limited of England. The unit, designed to rotate a shaft to any one of 12 positions set up independently, with an accuracy of within six minutes of arc, is available for 12-48 volt d-c operation in two panel sizes and with a torque of either 35 oz-in. or 60 oz-in.

CANADIAN DISTRIBUTOR for Boving Butterfly Valves is now James Howden and Company of Canada Limited of Scarborough, Ontario. Basic standard range will comprise valves of from 18 in. to 72 in. diam., but larger units are available.

PLANS for a method of constructing a unique type of underground sewage lift station employing electric submersible pumps are available from Flygt Canada Limited of Montreal. The station is CSA-approved and its design enables maintenance to be carried out without anyone entering the sump.

WELDING POWER SOURCES for use with manual and automatic gas-shielded metal-arc welding equipment have been recently marketed by Air Reduction Canada Limited of Montreal. These new welders are capable of providing constant arc voltage output, or varying degrees of down slope. The machines are rated at 300 amp., 100% duty cycle and 500 amp., 100% duty cycle. The 300 amp. d-c rectifier Aircomatic CV welder is of vertical design and provides continuous infinite down slope adjustment through a hand wheel. The 500 amp. d-c rectifier is of horizontal design and can be used for welding with all diameter wires where conventional constant arc voltage or down slope is required. Fourteen different down slope adjustments are obtainable by reconnection of leads accessible through a panel on the side of the welder.

EFFICIENCY can normally be increased 5 to 20% by properly converting coal and oil designed equipment to natural gas. This is the theme demonstrated by a mobile training and display unit designed and built by Northern Ontario Natural Gas Company. Efficiency tests

(More Briefs on page 167)

• MORE BRIEFS

are run for the purpose of proving the economy of converting existing heating plants to natural gas by the installation of low cost natural gas conversion burners.

COLUMN RESEARCH COUNCIL announces the publication of its Guide to Design Criteria for Metal Compression Members. This 112-page book presents a condensed summary of design criteria based upon recent and past research on metal compression members in building and bridges. It is written specifically for the engineer who either meets special problems not covered by standard specifications or is himself engaged in the preparation of specifications for such structures. The price of the book is $5 and it may be ordered from the Column Research Council, University of Michigan, Ann Arbor.

A HEATLESS, reactivating dehydrator which produces ultra-dry air or gas equivalent to a dewpoint of −180°F. is being marketed by Lear Industrial Products of Grand Rapids, Michigan. Unlike other heatless, continuous-duty dehydrators, this dehydrator cycles only as required for maintaining the flow of dry air. It is simple to install and operates on 115-a-c, 60 cycle current. The system provides up to 25 SCFM of air so dry that it contains less than 1/10 part per million water vapour by volume. Since the dehydrator filters as well as dehumidifies, its use is ideal for mermetically sealed instruments and for equipment such as bombsights, gyros, optics and cameras.

THE AMERICAN DRAFTING STANDARDS Manual, Section 15, Electrical Diagrams has been approved by the American Standards Association and published by The American Society of Mechanical Engineers. This is the first American Standard to deal with the actual preparation of electrical diagrams. It includes detailed recommendations on preferred practices for use in the preparation of electrical diagrams. This standard represents the first part of the work on electrical diagrams of the type used by the electronics and communications industries. Price is $1.50 per copy.

STRAPPING TENSIONERS of new design have been released by the Signode Steel Strapping Company of Chicago. They apply the principle of the self-energized feed wheel to manual heavy duty strapping operations. Grip of the new tools enables them to apply 1 to 1½ tons of tension per strap. They use coil-fed strapping to eliminate additional waste inherent in cut-to-length strapping, and are designed to slide easily from under the strap after sealing.

AN AIR OPERATED Sliding Gate and Plate Pressure Reducing Valve, with a capacity of 50,000 lb. of steam per hour or 2,500 g.p.m. of water, is now available in 4 in. and 6 in. sizes from OPW-Jordan Corporation of Cincinnati. The

(More Briefs on page 176)

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valve is used to reduce pressure wherever large capacities, accurate control and tight shut-off are required. The system is suitable for pressure to 250 p.s.i. and temperatures to 500°F. The sliding gate and plate seats are self cleaning and self-lapping to give tight shut-off and minimum maintenance.

LABORATORIES which need to cap relatively few concrete cylinders will be interested in the new basic cylinder capping set for preparing compression test specimens designed by Soiltest Inc., of Chicago. The new set, for vertical type capping, includes all items needed for efficient capping of 6 in. by 12 in. cylinders. The sets are in conformity with ASTM test methods C-31 and C-192 and AASHO test procedures T-23 and T-126.

GAS-FIRED INFRA-RED burners with controlled-wavelength radiant emission for high-efficiency heat transfer have been designed specifically for low-temperature industrial processing applications. Bryant Industrial Products Corporation of Cleveland reveal the face temperature of the 4 in. by 18 in. burner screen is 1200 to 1800°F. The nominal heat output is 30,000 B.t.u. per hr. per unit; each unit has a built-in flame adjustment—the first adjustable infra-red burner available. Applications for the new burner include drying metals, curing shell molds and foundry cores, drying porcelain enamel frit on metals, drying moist fabrics, paint and enamed baking and radiant heating for any other low-temperature processing need.

HIGHWAY CONSTRUCTION COSTS are dropping slightly, reports the U.S. Bureau of Public Roads. Notes, comments, and statistics pertaining to highways are reported by the Better Highways Information Foundation, organized recently in Washington, D.C. The Foundation is a non-profit, educational organization established to develop wider understanding of the need for and benefits of modern highways.

Preprinted
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MEMBERSHIP

CCAB BNA

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The Applied Science
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FRIGIDAIRE

Meet the Authors

John S. G. Shotwell, M.E.I.C., B.Sc. (McGill '25), M.Sc., Ph.D., President, John S. G. Shotwell & Associates, Ltd., Ottawa *(Canada's Energy Sources to 1989 — A Forecast).*

Following his Ph.D. at Columbia Mr. Shotwell was a research engineer with Price Bros. & Co., Ltd. and later Vacuum Oil Company in Paulsboro, N.J. In 1934 he established a consulting practice and in 1958 organized his present firm which this year became affiliated with William H. Byrne, P.E. Consulting Engineers, N.Y.

Wojciech A. Grobicki, B.Sc. Electrical (Polish University College, London, England '51), Electrical Project Engineer, Ewbank & Partners (Canada) Limited, Toronto; **David K. Whish,** B.Sc. (Newport Technical College, England '44), Senior Mechanical Engineer, Ewbank & Partners (Canada) Limited, Toronto *(Saskatchewan Power's Boundary Dam Generating Station).*

Mr. Grobicki worked for one year for Balfour, Beatty Co. on power station design. After coming to Canada in 1952 he was with the telecommunication equipment division of Northern Electric in Montreal until 1956.

Mr. Whish served three years with the Royal Engineers. He spent two years on design and field construction of high-pressure water tube boilers and other plants for steam power stations with Mitchell Engineering Limited. He joined Ewbank & Partners in 1950.

J. Lawrence A. Carey, M.E.I.C., B.Sc. Civil (U.N.B. '49), Engineer on Special Projects, Montreal Engineering Company, Limited, Calgary. *(Whitehorse Rapids Power Development).*

Mr. Carey was Montreal Engineering resident engineer on the Menihek Hydro Development in Laborator, the Whitehorse Rapids Development in the Yukon and the Brazeau Hydro Project in Alberta. He was also the Canadian liaison engineer on the Umtru Hydro Project in Assam, India.

R. A. Pillman, JR.E.I.C., B.A.Sc. Civil (U.B.C. '48), Executive Engineer, H. G. Acres & Company Limited, Niagara Falls; **H. R. Hopper,** JR.E.I.C., B.Sc. Civil (Manitoba '50), Project Engineer, Kelsey Generating Station, Manitoba Hydro Electric Board, Winnipeg; **D. H. MacDonald,** M.E.I.C., B.A.Sc. Civil (Toronto '45), Ph.D., Geotechnical Engineer, H. G. Acres & Company Limited, Niagara Falls. *(Kelsey Generating Station Dam and Dykes).*

Mr. Pillman has been with his present firm since 1948, and has in recent years been in charge of the co-ordination of engineering for large hydro-electric projects.

Mr. Hopper was with the Manitoba Department of Highways for a short while after he graduated. In 1951 he worked on the Red River Basin Investigation for the Water Resources Division, Department of Resources and Development. He joined the M.H.E.B. early in 1952

Mr. MacDonald was a structural engineer and testing engineer on the Yonge Street Subway for the Toronto Transportation Commission. After obtaining his Ph.D. from the University of London, England, he joined H. G. Acres and is now in charge of their Geotechnical Department.

H. Brian White, M.E.I.C., B.Sc. Civil (Toronto '44), Sales Development Division, Transmission Structures, Aluminum Company of Canada, Limited, Montreal. *(Chute-des-Passes 345 K.V. Transmission Line).*

Mr. White lectured in Civil Engineering at the University of Toronto for three years before joining B.C. International Engineering Company. He joined Alcan in 1954 in the Conductor Division, and was later transmission engineer responsible for the design and construction of the Chute-des-Passes transmission line.

Alastair R. Scott, B.Sc. (Edinburgh '44), Power Systems Application Engineer, Canadian General Electric Company Limited, Peterborough. *(Automation in Thermal Power Plants).*

Following technical service in the R.N.V.R. Mr. Scott joined the British Electricity Authority in Glasgow. He came to Canada in 1955 and joined Canadian General Electric. His present work includes application problems on utility and industrial power systems.

James R. McMullan, B.A.Sc. Electrical (Toronto '49), Design and Application Engineer, James R. Kearney Corporation of Canada Limited, Guelph, **J. Howard Myers,** Manager of Engineering, James R. Kearney Corporation, Guelph *(Standard Aluminum Substation Structures).*

Mr. McMullan was in the Engineering Department of Eastern Power Devices Ltd. of Toronto from his graduation to 1955. He then joined his present firm.

Mr. Myers spent six years with Reliance Electric prior to eighteen years on transformer design with English Electric. He joined his present firm last year.

Leonard A. Bateman, M.E.I.C., B.Sc. Electrical (Manitoba '42), M.Sc., System Planning Engineer, The Manitoba Hydro-Electric Board, Winnipeg. *(Long Range Hydro Planning for Manitoba).*

Mr. Bateman started in the design office of the City of Winnipeg Hydro-Electric System as a junior engineer and was subsequently appointed operating engineer, and general superintendent in charge of production. He resigned from the latter position in 1956 to take his present job.

W. F. Allen Jr., B.Sc. (Brown University '41), M.Sc., Mechanical Engineer, Stone & Webster Canada Limited, Toronto; **H. A. Smith,** B.Sc. Electrical (Queen's '40), Assistant General Manager of Engineering, The Hydro Electric Power Commission of Ontario, Toronto *(Lakeview and R. L. Hearn Generating Stations Design).*

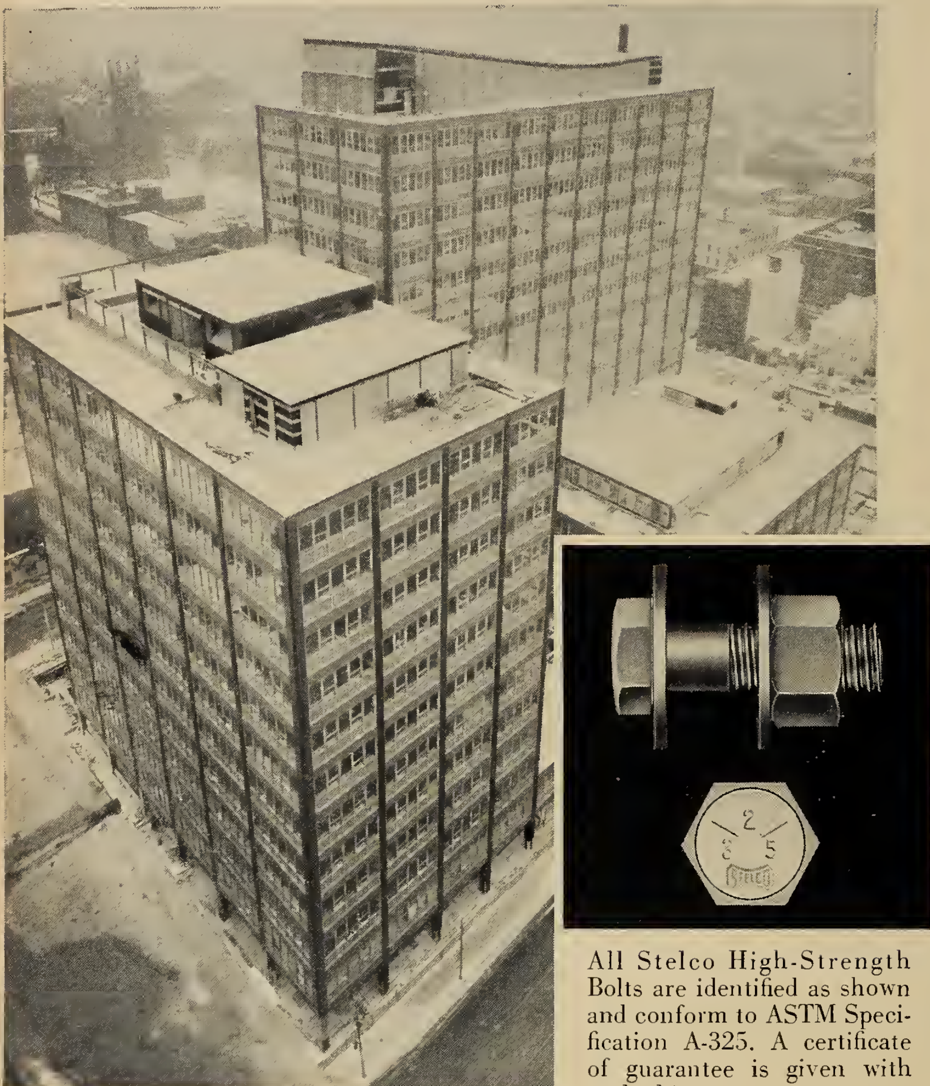
Mr. Allen was a Teaching Fellow at Harvard in 1947 and then joined the Boston engineering department of Stone & Webster. From 1950-54 he was in charge of the Heat Cycle and Special Studies Group. He has recently been project engineer on major steam-electric generating stations.

Mr. Smith's former positions with Ontario Hydro include assistant to the assistant electrical engineer; assistant to the director of engineering; frequency standardization engineer; co-ordinator nuclear power group; and director of nuclear power project. At Chalk River he initially served as project co-ordinator of a team carrying out joint studies on the feasibility of generating power from nuclear reactors.

COVER ILLUSTRATION

Symbolizing Power in Canada is this section of an air blast circuit breaker in the Cornwall switching station of the Hydro Electric Power Commission of Ontario's St. Lawrence Seaway development.

BOLTED BEAM AND COLUMN CONNECTIONS



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ARCHITECTS: Shore & Moffat, Toronto.

GENERAL CONTRACTORS: Redfern Construction Company, Limited, Toronto.

STEEL FABRICATORS and ERECTORS: Frankel Steel Construction Limited, Toronto.

High-strength bolting and welding were employed to erect the steel framework of this modern Canadian Government Building which houses a Post Office and other Federal Offices.

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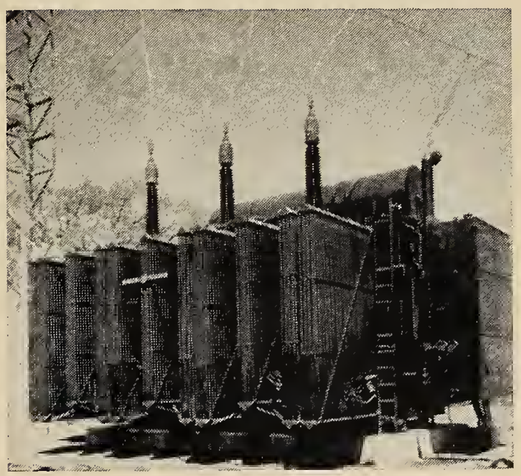
POWER IN CANADA



POWER PRODUCTION in Canada continues to increase. Through the first six months of 1960 total net generation of electric energy rose 10.2% above the corresponding period the previous year.

The Dominion Bureau of Statistics, reporting on firms which produce 10 million kwh. a year, said that in June power production totalled 9,132,588 Mwh. This compares with 8,289,846 Mwh. being generated in the corresponding period in 1959.

Generation by utilities rose 9.7% to 7,162,722 Mwh., while produetion by industrial establishments increased 12% to 1,969,866 Mwh.

Of the net generation between December 1959, and July, about 78% was produced by utilities. Utilities produced 44,895,987 Mwh., including 2,699,842 Mwh. of thermal power. The remainder was hydro.

Industry produced 12,419,424 Mwh., including 11,246,746 Mwh. of hydro and 1,172,678 Mwh. of thermal power.

Net generation of power has more than doubled in the last 11 years. Respective totals in 1949 and 1959 were 50,064,048 and 103,843,029 Mwh. last year. This trend is continuing in 1960.

Thermal and Hydro Power

Installed capacity of water-power plants at the end of 1959 totalled 24,888,426 hp. The total for thermal generating plants was about 3,785,979 hp.

For the second consecutive year a record was established for the amount of new hydro power brought into operation. A total of 2,508,800 hp. of new capacity was added. Major installations during 1959 were made at the Robert H. Saunders-St. Lawrence Generating Station of the Hydro-Electric Power Commission of Ontario where the nine remaining units totalling 675,000 hp. were placed in service, at the Chute des Passes generating station of the Aluminum Company of Canada, Limited, where three units totalling 600,000 hp. started operating, and at the Bersimis II generating station of thc Quebec Hydro-Electric Commission where three units totalling 513,000 hp. were placed in service.

Canada's total installed hydro capacity remains at less than 30% of the feasible turbine installation based on the country's estimated water power resources.

New thermal developments, or extensions to existing facilities, were under construction in nine of the provinces and in the Yukon and Northwest Terrtories. Significant increases in thermal installations were made in Alberta, Saskatchewan, New Brunswick and Nova Scotia where the greater part of the total requirements is derived from thermal plants.

Another significant increase in thermal power was made in British Columbia, where the first major thermal installation started operating in 1958.

Ontario showed the greatest increase, however, as the development of principal hydro-electrie sites within economic transmission distance of present load centres has largely been completed.

This growing tendency towards increased thermal-electric generation in various provinces reflects not only the fulfilment of the rapidly-increasing energy demand, but also the benefits of resources conservation which may be derived through the operation of an integrated power system supplied by both hydro-electric and thermal-electric plants.

Following is an outline of the main features of power in Canada, dealt with province by province.

BRITISH COLUMBIA

At the end of 1959 the west coast province was third in installed capacity of hydro power with turbine capacity of 3,509,460 hp. and fifth in thermal power with an installed capacity of 319,247 hp. British Columbia ranks second in recorded available hydro resources.

Considerable power potential exists principally in such rivers as the Columbia, Fraser, Peace and the Stikine. Much of the present development is in southern B.C., but the largest single development is the Kemano plant of the Aluminum Company of Canada with a present capacity of 1,050,000 hp. The British Columbia Electric Company, Limited is the major hydro producer and distributor in the province. The British Columbia Power Commission, organized in 1945, also has become an important power producing and distributing agency.

During 1959 a total of 199,000 hp. of new capacity was put into operation. Another 198,000 hp. are scheduled by the end of this year while various projects totalling 229,200 hp. are planned for development in later years.

B.C. Power put its new 35,000 hp. hydro development on the Ash River, Vancouver Island, into operation last year. In the planning stage are the Commission's Kokish River development on Vancouver Island where a development of 51,500 hp. is anticipated, and the Pyramid Mountain-Murtle River development which will consist initially of one unit with a turbine rating of 43,000 hp. It is proposed that this project eventually will consist of four 43,000 hp. units.

In the thermal-electric field the Commission finished its Georgia Generating Station at Chemainus, Vancouver Island. The plant consists of four gas turbines connected to identical generators, each rated at about 29,168 hp. at 85% power factor.

Work continued on the final phase of development of B.C. Electric's Bridge River No. 2, including construction of Mission Dam on the Bridge River. Initial operation of the new power house started late in 1959 with the completion of two 82,000 hp. units. Two similar units are to be added this year. Mission Dam will raise the head at Bridge River No. 1, increasing its output to 276,000 hp. from 248,000 hp.

Installation of a 6,000 hp. unit is planned this autumn at the Falls River development, Big Falls Creek. This will raise to 12,000 hp. the total installed capacity of the Northern British Columbia Power Company Limited plant.

The City of Revelstoke is planning to install a 5,700 hp. unit on Cranberry Creek, about 15 miles south of Revelstoke. Provision will be made for a second similar unit.

The Peace River Develpoment Company continued its planning of a project above Hudson Hope. Preliminary plans indicate this project will consist in part of a main storage dam where hydro-electric facilities under a maximum operating head of 600 ft. will provide a generating capacity of about 3,350,000 hp. A second dam and hydro-electric plant are expected to be developed downstream from the main dam.

Northwest Power Industries Limited maintained an active interest in the Yukon River power project and in the Nass River project. Review of main features of the Nass River project was undertaken and estimates for both projects were revised.

The governments of Canada, the United States and British Columbia continued active negotiations toward early development of the Columbia River in Canada.

ALBERTA

Alberta ranks sixth in installed capacity of hydro-electric power with 312,595 hp. at the end of 1959, and second in thermal capacity with 680,157 hp.

Principal hydro-electric developments from which Calgary Power Limited serves a large part of the southern portion of the province, are located on the Bow River and its tributaries. A substantial share of the water power resources are located in the northern half of the province, rather remote from present population centres. Large reserves of coal, oil and natural gas in the province supply a substantial portion of its power requirements.

In the thermal field Calgary Power began installing this year a 201,072 hp. steam turbine in addition to its Wabamun plant where two units with generating capacities of 88,472 hp. each are currently in operation. The new unit is expected to be in operation late next year. Late last year the City of Edmonton brought into operation a new 40,214 hp. Brown Boveri gas turbine unit at its municipally-owned thermal-electric plant. Addition of the new unit raises the plant capacity to 241,-287 hp.

Canadian Sugar Factories Limited installed a 2,245 hp. unit at Taber. Canadian Utilities Limited installed a 683 hp. diesel generating unit at the new town site of Swan Hills in northern Alberta. Northland Utilities Limited installed a new 670 hp. generating unit at its diesel plant at Lac La Biche.

No new hydro units were brought into operation last year but 102,000 hp. of new capacity are expected to be in operation by the end of 1960, and considerably more in later years.

Calgary Power resumed construction of extensions to its Spray and Rundle plants in the upper Bow River basin. This work started in 1957 but was suspended in 1958. Capacity of the Spray plant is being doubled by the addition of a 62,000 hp. unit while a 40,000 hp. unit is being added to the Rundle plant which now has a capacity of 23,000 hp. Both are scheduled to be finished this autumn.

Calgary Power also has started a new hydro development on the Brazeau River at Big Bend, about 15 miles upstream from where it joins the North Saskatchewan River. The first unit will have a 200,000 hp. capacity and plans call for construction of three additional 200,000 hp. units.

The company also is investigating a hydro-electric development at the Brazeau Forks site on the North Saskatchewan River, below its confluence with the Brazeau River.

SASKATCHEWAN

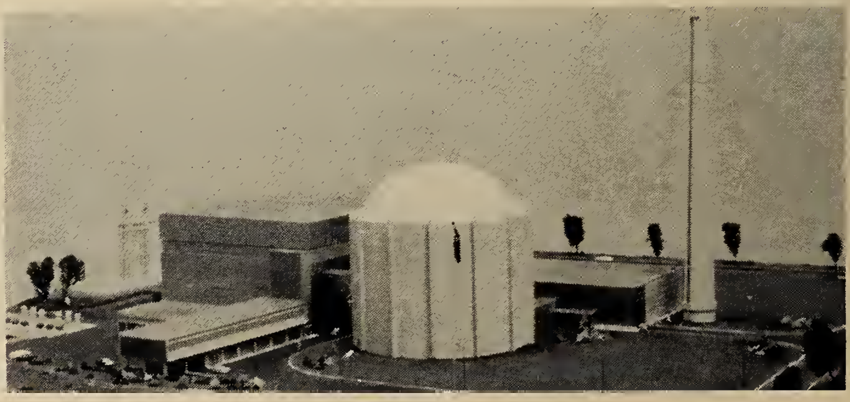
Saskatchewan is ninth among the provinces and territories in hydro-electric capacity and ranks third in thermal capacity. Installed hydro capacity is 128,835 hp., and installed thermal capacity is 622,524 hp.

Abundant water power resources are located in the northern part of the province, principally on the Churchill and Fond du Lac Rivers and on the Saskatchewan River. Existing water power developments now are confined to mining uses in northern areas. However, new developments now under construction on the Saskatchewan River will be tied into the transmission network of the Saskatchewan Power Corporation of the provincial government. The Corporation serves the more settled areas and now is supplied exclusively by thermal-electric plants. As in Alberta the substantial reserves of coal, oil and natural gas located in the province supply much of its power requirements, particularly in southern Saskatchewan.

The Churchill River Power Company Limited, a subsidiary of the Hudson Bay Mining and Smelting Company, Limited, completed last year the installation of a 19,000 hp. unit, increasing to 125,500 hp. the installed turbine capacity in seven units. Work on Saskatchewan Power's Coteau Creek site on the South Saskatchewan River continues. The Corporation plans to install hydro-electric facilities at the earth-fill dam which the Prairie Farm Rehabilitaton Administration is building as an irrigation aid.

Initially the hydro development is expected to consist of three units of 50,000 to 60,000 hp. each. Two similar units will be added at a later date. The complete project is scheduled to be finished in 1966.

Model of the Douglas Point Nuclear Power Station



Another Saskatchewan Power Corporation project, this one at Squaw Rapids on the Saskatchewan River, has started. Four 46,000 hp. units are planned for service by 1963 and the remaining two by 1964.

Last year the Corporation doubled the capacity of its Queen Elizabeth Steam Turbine Plant at Saskatoon with the addition of a second 88,472 hp. steam turbine and generator. At the new Boundary Dam Generating Station at Estevan, the Corporation installed the first unit, a steam turbine of 88,472 hp. and now is building a second, similar unit at this plant.

Northland Utilities installed a new 670 hp. unit at its diesel plant at Uranium City, Sask.

MANITOBA

Manitoba is the most generously endowed of the Prairie provinces in the field of hydro-electric capacity. With an installed capacity of 778,900 hp. the province ranks fourth in hydro. Manitoba has an installed capacity of thermal-electric power of 252,990 hp. and ranks seventh.

Manitoba also has the largest water power resources among the Prairie provinces with great potential on the Churchill, Nelson and Saskatchewan Rivers.

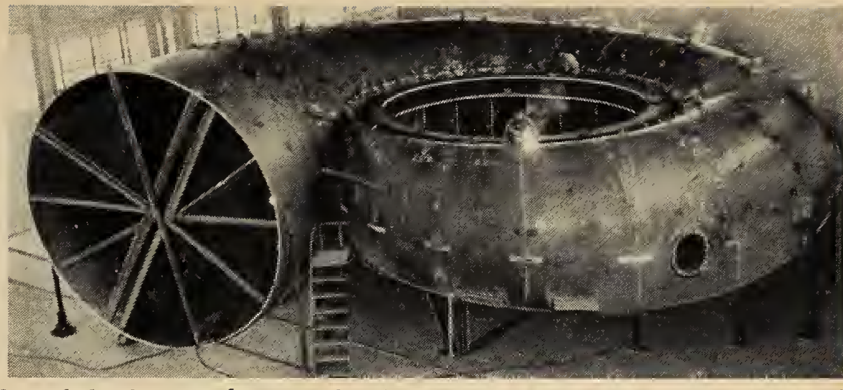
The larger present developments are on the Winnipeg River, now fully developed, and serve greater Winnipeg and the transmission network of the Manitoba Power Commission. Increasing amounts of thermal-electric power are being used to meet the increasing demands of the southern part of the province.

Construction continues at the Manitoba Hydro-Electric Board's Kelsey Generating Station on the Nelson River. Five 42,000 hp. units are scheduled for completion by the end of this year and provisions are being made for a sixth, similar unit. Also to be completed by this autumn for the Board are two 88,472 hp. steam turbine units at the Selkirk Generating Station.

ONTARIO

Ontario, which has developed the greater part of its recorded available hydro-electric power, ranks second with an installed capacity of 7,982,151 hp. It is first in thermal-electric power capacity with 1,080,303 hp.

The Hydro-Electric Power Commission of Ontario is the greatest power producing and distributing organization in Canada. It operates 69 hydro-electric stations with a total installed capacity of more than seven million hp. and two thermal-electric stations with a combined generating capacity of more than 900,000 hp. Its largest water power development is located on the Niagara River at Queenston where the total capacity of the Sid Adam Beck-Niagara Generating Stations No. 1 and 2, and associated pumping-generating stations is 2,521,000 hp. The Commission also buys about one million hp. on contract.



One of the four spiral casings for the Otter Rapids development on the Abitibi River.

Several major developments were completed for the Commission last year. They were: the Robert H. Saunders-St. Lawrence Generating Stations on the St. Lawrence River with seven units of 75,000 hp. each, increasing to 1,200,000 hp. the total installed capacity at the plant; Abitibi Canyon on the Abitibi River, a fifth unit of 66,000 hp.; Silver Falls, Kaministikwia River, the installation of a single 60,000 hp. unit.

At Red Rock Falls on the Mississagi River construction for the Commission continued for the installation of two 26,500 hp. units. The first is scheduled for service this December. At Otter Rapids on the Abitibi River work continued for the installation of four 60,000 hp. units, with minimum provision being made for the addition of four other units. Two units are scheduled for service next year.

Also completed last year was a single 30,300 hp. unit for the Great Lakes Power Company at Cat Falls on the Michipicoten River.

Thermal and Nuclear Power

A vital factor in the Commission's future plans is the development of power resources other than hydraulic. At the Richard L. Hearn Generating Station located in the eastern area of the Toronto waterfront the Commission plans to have all four additional steam turbines, each with a capacity of 268,000 hp. in operation by the end of this year. When finished the plant will have eight units totalling 1,608,000 hp. The Commission's thermal-electric capacity in southern Ontario will be further augmented by the installation of four 402,000 hp. units at the Lakeview Generating Station, now being built near Toronto. The first unit will be put in service in 1961 and the fourth unit is scheduled for completion in 1964. Plans now call for a total installation of 2,400,000 hp. at the station.

In conjunction with Atomic Energy of Canada Limited and the Canadian General Electric Company Limited the Commission is building a 26,800 hp. Nuclear Power Demonstration plant near Des Joachims Generating Station on the Ontario side of the Ottawa River. Atomic Energy of Canada Limited will build a 268,000 hp. nuclear-electric generating station on a 2,300-acre site between Kincardine and Port Elgin, on Lake Huron. When it has been demonstrated to be a satisfactory power source it has been proposed that the Commission buy the station at a price which will permit the production of energy at competitive cost.

QUEBEC

Quebec is the wealthiest of the provinces in water power resources, containing more than 30% of the total recorded for Canada. Quebec also ranks highest in developed power. Its present installation of 11,315,407 hp. is about 45% of the total for all provinces and represents the development of probably less than 40% of its feasible turbine installation.

In thermal-electric capacity Quebec ranks eighth, with 84,906 hp.

The largest single hydro-electric installation in Canada is the Quebec Hydro-Electric Commission's Beauharnois development on the St. Lawrence River with a capacity of 1,718,800 hp. installed to date. Also notable are the Commission's Bersimis I development on the Bersimis River with an installed capacity of 1,200,000 hp. and the Shipsaw plant of the Aluminum Company of Canada Limited on the Saguenay River which is rated at 1,200,000 hp.

Power production in the province is greatly facilitated by the regulation of stream flow by the Quebec Department of Hydraulic Resources through the storage dams it operates or controls.

The remaining two of Quebec Hydro's five 171,000 hp. units at Bersimis II were scheduled to have gone into service this month. At Beauharnois construction continued on the third and final section of the power house to contain 11 units of 73,700 hp. each. Operation of the third section started last year with the installation of four units totalling 294,800 hp. The remaining units were to have been installed at 2 1/2-month intervals and by 1961 the entire plant with a total rated capacity of 2,234,700 hp. is scheduled to be finished. Construction of Quebec Hydro's Carillon development on the Ottawa River started. There will be 14 units, each rated at 60,000 hp.

Alcan's Chute des Passes development on the Peribonka River was virtually completed early this year when the last three of five 200,000 hp. units were placed in operation.

Quebec Cartier Mining Company's Hart Jaune River development continues. Three 22,000 hp. units are scheduled for completion this autumn.

The Quebec Department of Hydraulic Resources continued its water power investigations on the Broadback, Rupert, Eastmain, Great Whale and Fort George Rivers in the James Bay watershed; on the Kaniapiskau River in the Lake St. John watershed and the Moisie, Sault-au-Cochon, Sault-au-Mouton, Portneuf and Escoumain Rivers on the north shore of the lower St. Lawrence River.

NEW BRUNSWICK

New Brunswick has about equal amounts of hydro-electric and thermal-electric capacity. It ranks sixth in thermal capacity with 258,066 hp., and is seventh in hydro capacity with 254,875 hp.

Although its water power resources are small compared with some of the other provinces they constitute a valuable power source of which considerable use is being made. As is the case with Nova Scotia it is favoured with abundant indigenous coal supplies.

The New Brunswick Electric Power Commission acquired ownership last year of the Grand Falls generating station on the Saint John River. Acquisition of this development from Gatineau Power Company Limited increased the Commission's generating capacity by 84,453 hp.

At Milltown on the St. Croix River, a reconditioned 500 hp. unit originally installed in 1910 and retired in 1920 was placed in operation last year by the Commission.

NOVA SCOTIA

Nova Scotia is in a power situation similar to that of New Brunswick. While it ranks fourth in thermal-electric capacity with 393,425 hp., it stands eighth in hydro capacity, with 183,168 hp.

As its neighbor, Nova Scotia has numerous rivers upon which moderate-sized power sites exist within economic transmission distance of principal cities and towns. Other sites are advantageously situated for use in development of timber and mineral resources.

The Nova Scotia Power Commission completed two developments on the Sissiboo River this year. There was an 8,000 hp. installation at Sissiboo Falls and a 12,000 hp. installation at Wymouth Falls. Developments by the Commission at Riverdale on the Sissiboo River and at Wreck Cove on Wreck Cove Brook are in active prospect with proposed installations of 10,800 hp. and 90,000 hp. respectively.

At Lequille on the Lequille River the Nova Scotia Light and Power Company Limited is building a single-unit 7,500 hp. development. This is scheduled to be finished next year. A single-unit 6,500 hp. development at Alpena on the Nictaux River is an active prospect for the Company, with completion expected in 1962.

PRINCE EDWARD ISLAND

Prince Edward Island suffers from the lack of large streams and consequently water power sites are limitted in size to those used for small mills. It ranks last in hydro capacity with 1,660 hp. and is 10th in thermal capacity with 34,023 hp.

The Maritime Electric Company is adding a 13,405 hp. unit for operation late in 1961 at its Charlottetown steam plant.

NEWFOUNDLAND and LABRADOR

On the basis of the limited streamflow data available Newfoundland's water power resources are estimated to be of considerable magnitude. On the Island, although the rivers are short, topography and run-off conditions are favorable to power development. The Hamilton River in Labrador is considered one of the largest undeveloped sources of water power in Canada.

Newfoundland ranks fifth in hydro capacity with 370,135 hp., and its thermal capacity of 55,981 hp. places it fifth in that category.

United Towns Electric Company Limited completed two installations, one late last year and one in 1960. At Pitmans Pond, New Chelsea Brook, a single 1,200 hp. unit was finished last November. The other project, installation of a single-unit 3,200 hp. development, was at Heart's Content on the Heart's Content River.

At Menihek Rapids on the Ashuanipi River in Labrador the Iron Ore Company of Canada this year doubled the existing plant capacity by the addition of a 12,000 hp. unit. For the Newfoundland Light and Power Company Limited installation of a single-unit 6,500 hp. development is in active prospect at Middle Brook near Gambo.

Also in active prospect as part of an ultimate development of 350,000 hp. is the installation of two 38,500 hp. units at Bay d'Espoir for Southern Newfoundland Power and Development Limited. In the same category is Hamilton Falls Power Corporation Limited's Scott Fall project on Labrador's Unknown River. Two 25,000 hp. units would be part of an ultimate development of 300,000 hp. This development on a tributary of the Hamilton River is one of three subsidiary projects which may be built prior to construction of the main features included in the plan for Hamilton River developments.

YUKON and NORTHWEST TERRITORIES

The two Territories which comprise Canada's vast northland possess extensive water power resources. But owing to light precipitation the favorable sites are dependent upon large storage facilities. In the Yukon Territory most of the resources are located on the Yukon River and its tributaries. There exists the possibility of diverting the headwaters of the Yukon River through the Coast Mountains to utilize a high head near tidewater in northern British Columbia. Such a development, however, would affect adversely the power potential of the Yukon River in the Yukon Territory. In the Northwest Territory resources are large, with more than one-half the total occurring in rivers flowing into Great Slave Lake. Present development is limited to local mining uses and the supply of attendant settlements.

The Territories now rank 10th in hydro capacity with 51,240 hp. and are 11th in thermal capacity with 4,357 hp.

At Snare Falls on the Snare River, N.W.T., the Northern Canada Power Commission is working on installation of a single 9,200 hp. unit with provision for a second similar unit. The first unit is scheduled for operation in November. The Commission also has added or is planning 1,340 hp. diesel units at Yellowknife, Frobisher Bay and Fort Smith.

CANADA'S ENERGY SOURCES TO 1989 — A FORECAST

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Presented to Power Section, E.I.C. Toronto Branch, September, 1959.

Canada's power engineers must face, at the present time, the problem of deciding what sources of energy the country will be using for its power plants, industries and other purposes in 1980. At first, 1980 seems a long way off and any attempt to forecast the principal sources of energy used then is a very wild guess. A second look at the engineering picture quickly reveals that this is not so.

A LARGE proportion of 1980's power plants are either already built, under construction or on the drawing boards at the present time.

This may seem strange until we remember that we usually design power plants to have a useful life of from 20 to 30 years and that it often requires from 10 to 15 years to transform somebody's dream into a major operating project.

Such "lead time" may seem long to some people; but, they must remember that every stage from the first hazy concept, through its design and construction to its acceptance and getting it into service takes time. First the engineers and economists make feasibility studies and site selections and prepare preliminary plans with estimates of cost and time required to build the project. These go to the Board of Directors and generally require several revisions before receiving approval. Then the engineers must prepare the contract drawing and specifications and get these approved before calling for tenders. Next we take time off while the various contractors study the documents, prepare their estimates and submit their bids. The owner and his engineers now require some time to review the bids, after which the construction contract is awarded, and construction drawings prepared and approved. All these stages require considerable time to complete before a single sod is turned or item fabricated. The actual construction of the plant, the fabrication and erection of equipment require time, although some of this may be saved through careful scheduling of the combined operations so that several operations which do not conflict will proceed at the same time.

If a major technological development occurs before the fabrication and erection of the equipment has proceeded too far; the owner, the engineers and the designers may decide to redesign the plant and equipment to take advantage of these advances. In so doing, they will set back the completion time and hold up the final acceptance of the plant.

The Long Branch Station of the Ontario Hydro-Electric Power Commission is an example of these time-consuming progresses. Although this plant was designed by 1958 it is only scheduled for full operation in 1968, ten years later. An examination of the Commission's records would probably show that the total time between the initial studies leading to the decision for a second thermal plant in the Toronto area to the final acceptance of the station at full operating capacity will exceed 15 years.

Thus, we may assume that any new large thermal power project conceived during the winter of 1959-1960 will be lucky if it reaches full productive capacity by 1975. And, if it incorporates any radically new engineering concepts and techniques it may not reach the full operational state until 1980. This will be the case, especially, if the new techniques, pressures, temperatures or fuels require the use of new alloys or ceramics.

The generally-accepted economic doctrines consider that because energy multiplies man's effort many fold energy and industry are synonymous. The wide use of inanimate energy to furnish light, heat and power for factories and to convert matter from one form to another strengthens the general acceptance of this concept. Modern industry, however, uses sources of energy both directly and through converting them into new materials on a much wider application then is generally conceived. It does this through the use of energy sources in the trades and services and also as raw materials in many new chemical and physical processes.

New commercial sources of energy, technological advances and improved designs will affect the trends and modify the consumption of every type of "fuel" used for any specific purpose. Nevertheless, 1980's newest heating units and power plants will be modifications of and forecastable improvements of those in use, under construction or on the drawing boards in 1959 and 1960. Exceptions to this broad statement may take place due to the rapid technological application of some process which is presently barely a passing idle fancy in some physicist's mind or a stray reaction in some chemist's test tupe. Or, somebody may develop a new alloy, ceramic material or plastic which will permit the use of higher temperatures and pressures, faster speeds or it may eliminate corrosion and erosion.

Assuming the above premises to be correct, the author will attempt in this paper to study the trends and forecast Canada's probable utilization of all sources of energy during the next 20 years. He will do this through consideration of the trends in: (1) the consumption of energy, (2) the various energy sources, and (3) the indicated technological advances during the next few years.

The Gordon Commission[1] thoroughly investigated the existing[2] and future use of fuels, power and energy by the various segments of Canada's economy. John Davis, the Commission's economic expert on energy matters, frequently reiterated that each energy-consuming segment of the community selects the course of energy it uses according to the suitability of the source for the particular end use and its technological advantages, the reliability of the source at the point of consumption and the economic factors of each application.[3] We shall discuss later these various factors and the changes which result when new sources of energy become available to any using sector of the community.

The pattern of Canada's economic development is changing rapidly and with the changes come alterations in the consumption and end use of each of the enercy sources. The transformation of Canada's economy from an agrarian to a heavily industrialized one has resulted in the discovery of many new sources of energy together with new uses for the old ones. The next 20 years will see these trends increase and, while many result in the conversion of a source of energy into a new material without the release of useful energy in the form of power or heat which may be transported and used elsewhere, these uses of energy sources must be included in our study because they may assist us to clarify our thinking and also they may disclose possible new fuels.

Thirty years ago space heating and transportation utilized nearly two thirds of the total energy used in Canada. At present these uses of energy have dropped to about 58% and by 1980 they will have dropped still farther to about 47%.

Although the percentage of the total energy used for these purposes (space heating & transportation) is dropping, the quantity of the fuel used is increasing (Table II & Fig. 2.) An examination of these show that the total fuel used for the two purposes has increased from the equivalent of 32.6 million tons of coal[4] in 1926 to 60 millions tons of coal at the present time and it will reach approximately 150 million by 1980.

At the time the percentage of the total energy and the quantity consumed by the public utilities in the production of power have increased from 7% to 15% and from 3.5 million tons in 1926 to 60 million tons in 1980. Similar increases are noted in the use of self-generated power by the mining and manufacturing segments of the community whose energy demand increased from 8.9 million tons last year and will probably reach 104 million tons in 1980. The non-fuel uses of the energy sources from coal, to oil and gas will rise from 3.0 million tons to 31 million tons of coal equivalent not including the employment of wood as the raw material.

We shall examine the various consuming segments of the economy and the various sources of energy in detail later; but first we shall review the bases for making predictions on the future uses of energy.

First we shall consider probable population increases, because the expansion of the country's industries and the country's demand for additional sources of energy depend largely upon population increase. We all recognize that population shifts affect the energy consumed of the country. For instance when large numbers of farm workers moved into urban areas and became industrial employees there was an increase in the total energy consumption. This increase is important, but it does not have the overall irresistible impact of an additional one or two million in population added to both industry and agriculture. Further, we must recognize the steady movement of industry into rural areas with the subsequent part-time employment of large numbers of farm works and the combined mechanization and electrification of the farms.

Fig. 3 shows the population increase based upon the figures given in the Gordon Report, the Canada Year Book and the reports of the Dominion Bureau of Statistics. The forecasts follow those of the Gordon Report using four premises. (1) All population growth is due to the natural rate of increase with no immigration; (2) the population based upon the assumed rate of increase chosen by the Gordon Commission (100,000 net immigration); (3) population growth continuing as the 1955-1959 rate of increase; and (4) the same as (3) but with the immigration to the United States and other countries stopped through the combined efforts of leaders in government, business and stopped through the combined efforts of leaders in government, business and labor circles. The curves in Fig. 3 indicated that according to these assumptions we should have a total population of (1) 24 million, (2) 27.5 million, (3) 32 million and (4) 33.5 million and possibly due to the added incentives nearly 40 million.

The simple increase in the population does not of itself, make radical changes in the energy demand. It will, of course, increase the energy demand proportionately with the population. If the population increase is accompanied by revisions in the country's economic structure such that the per capita consumption of energy is increased then we find that the final energy demand far exceeds that usually estimated. Hence, before we can make any reasonable predictions of the consumption of any energy source we must first examine the trends in the country's economic development, the various potential sources of energy (with their advantages and disadvantages) the cost of each source with its availability and reliability at any given point.

The close relationship between a country's economic growth and its

TABLE I

Canada's Changing Pattern in Energy Use

(As percentages of total energy used)

Consumption Sector	*1926*	*1958*	*1980*
Energy Industries	7	10	17
Mining and Manufacturing	18	24	29
Res. and Comm. Heating	37	28	23
Transportation	29	29	21
Non-fuel Uses*	3	5	9
Waste and Other	6	4	1
Total	100	100	100

* Non-fuel uses include those where the source is changed into another such as: matallurgical coke, coal tars, dyes, petrochemicals, lubricants, etc. It should include pulp, paper and other wood derivatives.

TABLE II

Canada's Changing Pattern in Energy Use

(As million tons of coal equivalent)

Consumption Sector	*1926*	*1958*	*1980*
Energy Industries	3.5	8.6	60
Mining and Manufacturing	8.9	30.0	104
Rest. and Comm. Heating	18.3	34.5	81
Transportation	14.3	35.0	74
Non-fuel Uses	3.0	6.5	31
Waste and Other	1.4	4.2	6
Total	49.4	118.8	356

energy consumption is well recognized. The wealthier and more industrialized countries have relatively high rates of energy use, while the poor countries with little or no industry have low rates of energy use and there is a parallel between the industrial development, the national income and the energy consumption of those in between. (Fig. 4 & 5).

While acknowledging the general relationship between economic development and energy consumption, we must realize that it is not universally apparent. It is often obscured by such factors as the non-commercial sources of energy used; changes in efficiency due to the conversion from one fuel to another; the losses involved in converting a source of energy to a more highly processed form (which may of course give greater useful efficiencies) and the conversion of energy sources into non-fuel uses.

The replacement of wood and agricultural wastes by the fossil fuels and water power often accounts for a rapid rise in measured energy consumption which may be misleading. This does not constitute a major problem in forecasting Canada's future energy requirements, because the non-commercial sources of fuel and energy do not form an appreciable percentage of the total requirements. There are two factors which we must consider later and those are the large quantities of wood which are destroyed by fire and the also large volumes of wood which are transformed into other and more-refined forms including alcohol and other chemicals.

The overall cost of energy affects a nation's economic development in the same manner that the cost of a particular energy source may affect its selection for a specific use. Fuel costs are an important factor in the power and the primary industries and may decide in the selection between two types. However, availability, quality and dependability of supply and flexibility in use are often far more important factors than mere cost in the final selection.

Each source of energy has specific purposes for which it is the most efficient and most economical. Even so, the improved methods of transportation and distribution of "Fuels" have widened the choice in energy sources available to Canadian consumers. The pipe lines and high tension transmission lines have released huge quantities of natural gas, oil and electricity from the restrictions of local demands to supplying the markets of almost country-wide extent.

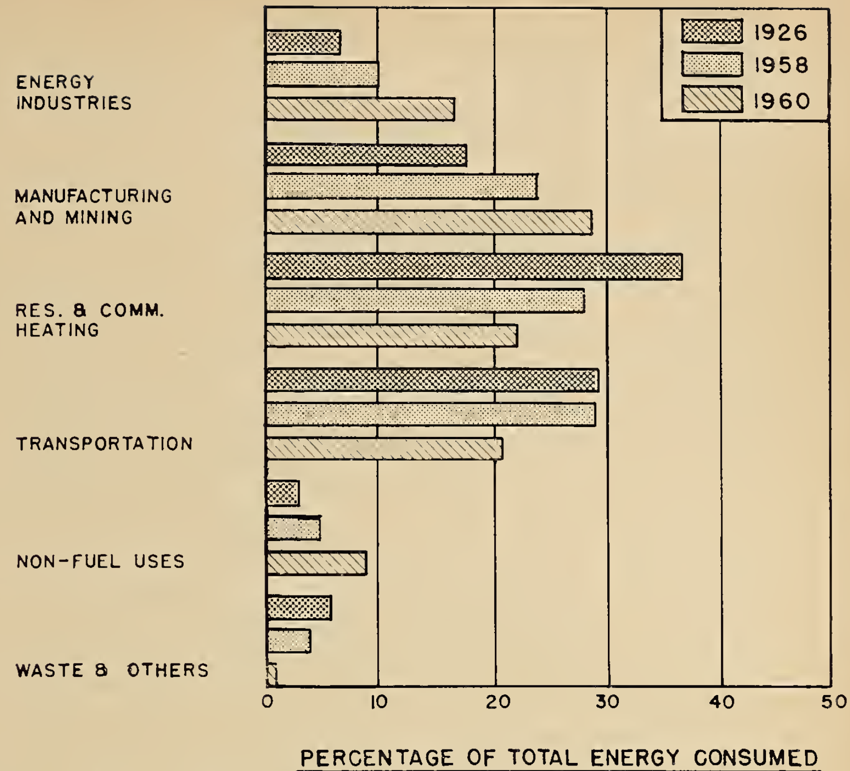


Fig. 1. Canada's changing pattern is energy use—energy consumed.

The past, present and future consumption of Canada's energy sources are shown in Tables III & IV, these are taken from the Gordon Commission Reports and are based on present marketing techniques. They further include the "non'-fuel" uses for coal, Petroleum and natural gas but only the direct fuel uses for wood. We shall later consider the effect of including the similar "non-fuel" uses for wood.

Many factors can alter the trends shown in the above tables. Changes in the merchandizing techniques of an industry can alter the picture completely. This is the case, especially, when the changes are the result of a long-range co-operative program of applied research. The petroleum and gas industries have shown the benefits of such long-range research programs which have developed new products, more-efficient methods of refining and transportation and more effective means of utilizing the products. The coal industry has just initiated a similar program and may regain some of its lost markets when the results of this research begins to seep down to the salesmen and users.

Again the enforcement of waste treatment legislation may result in the utilization of a waste for some useful purpose (many of the petroleum products such as gasoline were originally by-products) or it may result in the development of some new material from the wastes. Thus the pulp industry might enter the energy market with extremely cheap alcohol. This could completely alter the existing balance and force the gas and oil industries to re-assess their marketing policies.

Any well-planned concentrated drive for new markets brings interesting side chain reactions. This is so especially when the drive means the opening up of a new territory to new centrally, distributed fuels. For instance, the recent opening up of

TABLE III
Canada's Changing Energy Supply
(Millions of tons of coal equivalent)

Energy Source	*1926*	*1939*	*1953*	*1958*	*1980*
Coal	34.0	31.2	39.7	38	78.5
Petroleum	4.7	11.1	43.7	70	150
Natural Gas†	0.9	1.7	4.1	7.4	65
Water Power‡	1.6	3.9	8.0	11	36
Nuclear Energy	—	—	—	—	8
Wood	8.2	7.8	8.0	9	3
Total	49.4	55.7	103.5	135.4	340.5

†Including, Natural gas liquids
‡Measure as developed electric power

TABLE IV

Canada's Changing Energy Supply

(Percentages of total energy supply)

Energy Source	*1926*	*1939*	*1953*	*1958*	*1980*
Coal	69	56	39	28	21
Petroleum	10	20	42	52	45
Natural Gas	2	3	4	5	19
Water Power	3	7	8	8	11
Nuclear Energy	—	—	—	—	3
Wood	16	14	7	7	1
Total	100	100	100	100	100

Northern Ontario by the natural gas industry suddenly multiplied the sales of liquified petroleum gas (LPG), which the gas was expected to replace.

We shall now examine the main sources of energy in the country and after taking them in detail we shall consider how they may change their importance to the future.

Water power (hydro-electric power) has been the touch stone to Canada's industrial revolution. It is the key to the transformation of a fur trading and agricultural land into the world's fifth industrial nation within a space of 40 years. It will remain an important factor in the future, but undeveloped water power is no longer the sole key to the country's industrial expansion.

Ontario has already developed the last great hydro site within her confines. There are still some small projects which may utilize the potential energy of the few remaining unharnessed rivers; but, the majority of the future added requirements will come from thermal electric power stations, and by 1980 the Ontario Hydro expects nuclear stations will furnish one-third of its demand.

Quebec has only developed 40% of her water powers and so has considerable potential room for expansion before becoming entirely dependent upon thermal stations for new sources. The Ottawa, St. Maurice and Saguenay Rivers and their tributaries can still produce some 2.5 million kw. while the rivers of the North Shore of the St. Lawrence and those flowing into Hudson and Ungava Bays are barely reconnoitred. Even with these opportunities for hydro expansion, Quebec may need thermal or nuclear power stations in the near future to meet the demands for additional power in the congested Montreal district and in some of the remote Arctic sites.

Newfoundland possesses few undeveloped hydro power sites on the island itself, but the large Labrador rivers have over 5.0 million kw. of undeveloped potential water power. The British-Newfoundland Corporation is presently developing a 4 million kva. project at Grand Falls on the Hamilton River and other groups are investigating other sites.[5] These locations are so remote from the normal markets for power that they will require the development of the region before they can truly utilize their full potential.

Prince Edward Island possesses no undeveloped water power and the provinces of Nova Scotia and New Brunswick have a few of any magnitude, hence, these provinces must rely upon thermal stations to meet any large future demand unless they develop efficient and economical tidal-power stations.

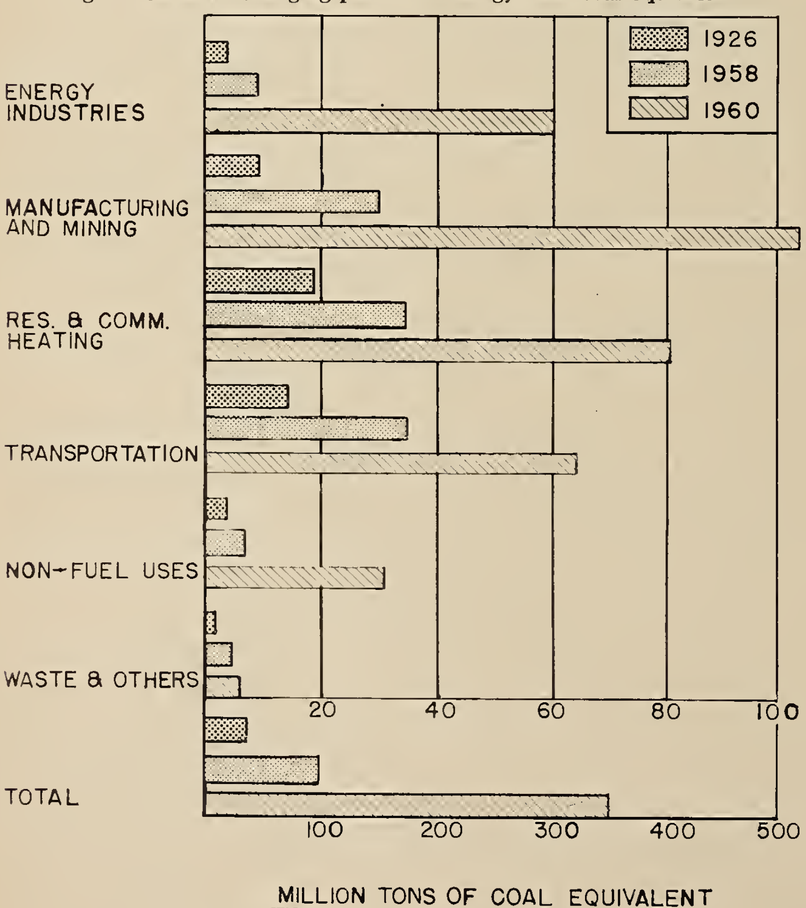
Tidal power is a form of hydro power and extensive research has been carried out by both American and Canadian bodies which have reported that tidal-power can operate effectively in the Bay of Fundy. At the same time, the need for furnishing markets for Maritime coal may well force the utilities to build thermal stations in these provinces.

Manitoba has sufficient undeveloped hydro sites on the Nelson, Saskatchewan and Churchill Rivers to assist in the development of the northern section of the province, the rich mineral region. The southern section of the province where its present population and industries occur possesses little undeveloped water power sites and this area will require thermal stations to meet any new demands.

Saskatchewan and Alberta possess little undeveloped water power and most of this is on rivers which are international in character and require the *approval of the International Joint Commission*. However, that body has recommended several projects and the Government of Canada has agreed with the province concerned to jointly build some of these developments.

British Columbia and the Yukon possess many large undeveloped water power sites. Unfortunately, most of these occur in remote areas so that their construction would probably be limited in usefulness to the development of restricted regions.

Fig. 2. Canada's changing pattern in energy use—coal equivalent.



This situation is apparent in the decision of the British Columbia Electric Company to build a large thermal-electric station to meet the growing demands of the Vancouver area.

TABLE V

Canada's Available and Developed Water Power

(thousands of kilowatts)

Province	*Available Power Minimum Flow*	*Installed Capacity*
Newfoundland	715	245
P.E.I.	—	1
Nova Scotia	19	132
New Brunswick	92	122
Quebec	8,128	5,950
Ontario	4,034	4,004
Manitoba	2,486	594
Saskatchewan	410	82
Alberta	379	213
British Columbia	5,239	1,694
Yukon & N.W.T.	285	25
Total............	21,787	13,061

The domestic use of electricity has risen rapidly in the last 15 years with the great increase in the use of electric washing machines, driers, stoves and refrigerators. The general use of blowers, or oil burners for house heating has added to the demand. While the Canadian householder pays approximately the same proportion of his usable income for power and fuel, as his American confrere, he uses about 1.6 times the amount of electricity as does the householder south of the border.

The industrial demands are increasing with the growth of industry as is shown in Table VI.

The forecast by Mr. Davis[6] was prepared on the basis of usages in 1955. Recent developments in the commercial and domestic electric loads indicate that the total demands for these classes of customers will be much higher than anticipated.

The current practice of commercial lighting is to use 100-150 ft. candles instead of the 20-50 ft. candles used at the time of the forecast. This will probably increase the commercial demand in 1965 and 1980 by at least 25%. In addition the heat given by this lighting necessitates cooling of the lighting fixtures and dissipation to either the outside of the buildings or at least to the areas adjacent to the exterior walls and may even eliminate the need for supplying any other heat even during extreme winter weather.

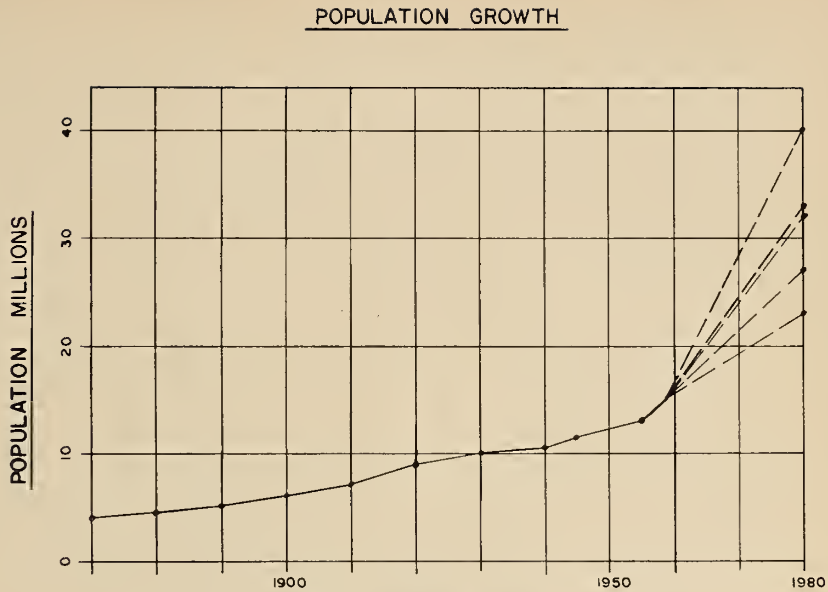


Fig. 3. Population growth.

The electric industry is taking advantage of the trend to radiant heating in both commercial and domestic fields. With the 90% efficiency of transforming electric power at the bus bar to heating in the store, office or home, electricity can compete economically with the other forms of fuel when power is available. The public utilities are taking this into consideration in their expansion plans. This is evidenced in a speech made by a Vice-President[7] of the West. Penn Power Company of Pittsburgh in June 1958, in which he stated his company was experimenting with electric home heating commercially and that they expected to have their share of this market by 1965 and at least 40% of the new homes by 1970.[7]

Coal will continue to supply an increasing amount of the country's energy supply through 1980, even though the percentage of the total energy demand supplied by coal gets smaller. The total tonnage of coal used in Canada in 1958 was 3.0 million tons greater than that used in 1926 although the percentage had shrunk from 69% in 1926 to 29.9% in 1958. It is expected that the nation's coal requirements will grow so that in 1965, 37.4 million tons and in 1980 78.5 million tons will be used. These increased tonnages will, however, only mean 26.1% and 21% of the total energy used in all forms.

The amount of coal used for domestic heating and for transportation decreased by approximately 6.1 million tons between 1926 and 1953 but this loss plus nearly six million more tons was made up by the additional coal used by the iron and steel plants, industry in general and the thermal electric power stations.

The forecasts by the Gordon Commission and the Dominion Coal Board estimate that by 1975 the an-

TABLE VI

Electric Power Consumption by Consuming Sectors

	1953 Consumption		*1965 Consumption*		*1980 Consumption*	
Consuming Sector	*MMkwh.*	*%*	*MMkwh.*	*%*	*MMkwh.*	*%*
Pulp and Paper	14,715	21.9	23,000	14.4	35,000	9.1
Mining	2,782	4.0	7,000	4.3	17,000	4.4
Primary Iron and Steel	1,927	2.7	5,000	3.1	13,000	3.4
Smelting and Refining	13,087	18.7	32,000	20.1	95,000	24.6
Abrasives	1,927	1.5	1,700	1.1	3,000	0.8
Chemicals	3,970	5.7	11,000	6.9	20,000	5.0
Secondary Manufacturing	6,199	8.8	13,000	8.1	25,000	6.5
Domestic Demand	9,878	14.1	25,000	15.6	75,000	19.6
Commercial Light and other Services	7,603	10.9	18,000	11.2	45,000	11.6
Exports	2,424	4.5	8,500	5.3	20,000	5.0
Losses	6,364	9.1	16,000	9.9	39,000	10.0
Total	69,979	100.00	160,000	100.00	387,000	100.00

nual coal, requirements for Canada's thermal-electric plants will reach 27 million tons and that by 1980 the demands may reach 40 million tons. In addition industry will use 26 million tons in 1975 and 28 million tons in 1980. Thus, the combined total coal used by industry and the production of electricity in 1975 will be 156% of the 1926 total for all purposes and that for 1980 will be 200% of the 1926 grand total. Table VII shows the estimated demands by their principal uses.

The rapid expansion of thermal electric generation is the direct result of the nation's demand for more power than hydro-electric development can supply and this has resulted in a growing demand for more and more coal. The public utility companies, after carefully surveying the fuel situation, designed the central stations to operate at near critical pressures and temperatures with burners which can be operated on coal, oil or gas. In most cases the operators select coal as their regular fuel, although it requires expensive coal and ash handling equipment and space for large storage piles but, it is economical, reliable and less subject to interruption in supply provided that the plant has sufficient storage.

Thermal power stations will furnish nearly one-third of the additional generative capacity and 30% of the total generative capacity required to meet Canada's power demands by 1980. These plants will be built in all provinces.[8,9].

Coal will maintain, generally, its use as the fuel for space heating and process steam plants, which due to size or pressure require the full-time employment of a boiler room attendant. These larger plants usually find the fuel economics for coal, except for Alberta and Saskatchewan, outweigh the apparent advantages for oil and gas. It might be pointed out here that several large chemical plants are presently converting to and using gas with the intention of establishing a present demand for this material so that they can use it as a raw material for synthetics in a few years when the Canadian demand for those materials warrants their production in Canada.

Coal — high grade coking coal — is an essential major raw material for the rapidly-expanding iron and steel industry. Steel mills require continuous supplies of suitable coal in very large tonnages. This demand has restricted the industry to sites which are easily, economically and continuously supplied with iron ore, coal, limestone, and fantastic quantities of water. Hence the industry's major expansion will probably continue along the shores of the Great Lakes, the Upper St. Lawrence and in Nova Scotia. However, it is extremely possible that Provincial and Dominion policy may result in steel mills in Labrador, the Lower St. Lawrence and Ungava. This action might be accelerated by the development of commercial direct reduction of the ores by hydrogen in electric furnaces.

Petroleum products have replaced solid fuels in many fields, thanks to their ease of storage and the close quality control maintained in their preparation and manufacture. They have dominated the transportation field through their many advantages. In ships the elimination of "wing" and "cross" coal bunkers has liberated space for valuable cargo carrying; and double bottom tanks largely devoted to carrying ballast water can now carry the ship's requisite fuel oil. They can fill their tanks in less than a quarter of the time required for coaling and they can trim ship easily by pumping oil from one tank to another. Finally, they can store more heat units in the same space than they can with coal.

This employment of waste space has less apparent effect on land than its greater flexibility and the greater efficiency of the diesel-electric locomotive and truck over coal-fired steam driven ones. The flexibility of the internal combustion engine and the ease of storing fuel are factors in the domination of petroleum fueled buses, trucks and cars for highway traffic. Without oil and the internal combustion engine, man could never have conquered the air.

Oil's freedom from dust and ashes and its small space requirements for storage combined with the easy application for automation makes it an ideal domestic heating fuel. This has assisted it to replace solid fuels for domestic heating, as it is presently being supplanted by gas and, to a limited extent, by electricity.

In addition to its advantages in fuel fields, oil has become the important raw material in the manufacturer of an ever-widening range of chemical-products. This use of oil has risen from 6,000 barrels a day in 1956 to 13,000 barrels a day in 1958 and may reach 60,000 barrels per day by 1980.

Eastern Canada's reliance upon foreign sources of crude oil may effect the ultimate development of this source of energy. This may be overcome through the construction of pipelines to carry Western Canadian crudes to Sarnia, Toronto and Montreal. The Borden Commission did not bring down a definite and clear-cut recommendation on this point. Even so, the 1980 demand for the country should exceed 1,753,000 barrels per day.

From the above, we can expect that by 1980 petroleum products will fill the following uses:

(a) Space heating: oil will increase for this use, although the proportion of its use for this purpose will decrease both within the petroleum products and in comparison with other fuels after 1960;

(b) Transportation: It is the fuel for highway and air transportation

TABLE VII

Consumption of Coal by Principal End Use

(Millions of short tons)

Consumption Sector	*1926*	*1955*	*1965*	*1975*	*1980*
Space Heating	10.0	8.3	5.0	2.0	2.0
Transportation	10.0	6.0	1.3	0.7	0.5
Mining and Manufacturing	7.1	10.5	11.3	12.0	13.0
Iron and Steel	2.9	5.5	10.0	14.0	15.0
Electric Power	0.5	1.8	8.0	27.0	40.0
All Other	1.2	1.7	1.8	5.0	8.0
Total	31.7	33.8	37.4	60.7	78.5

TABLE VIII

Consumption of Petroleum by Uses

(thousands of barrels per day)

Consuming Sector	*1928*	*1950*	*1955*	*1960*	*1980*
Aviation	—	5.4	15.8	19.8	46.1
Automotive	36.4	144.9	222.2	288.8	565.3
Railway	5.2	19.4	32.2	35.8	45.8
Marine	11.0	20.8	25.4	28.8	42.5
Residential	3.5	59.2	136.7	187.4	312.6
Industrial and Others	12.4	107.9	179.9	233.3	690.3
Fuel conversion	6.2	9.1	10.7	13.8	50.5
Total	74.7	366.7	622.9	807.7	1753.1

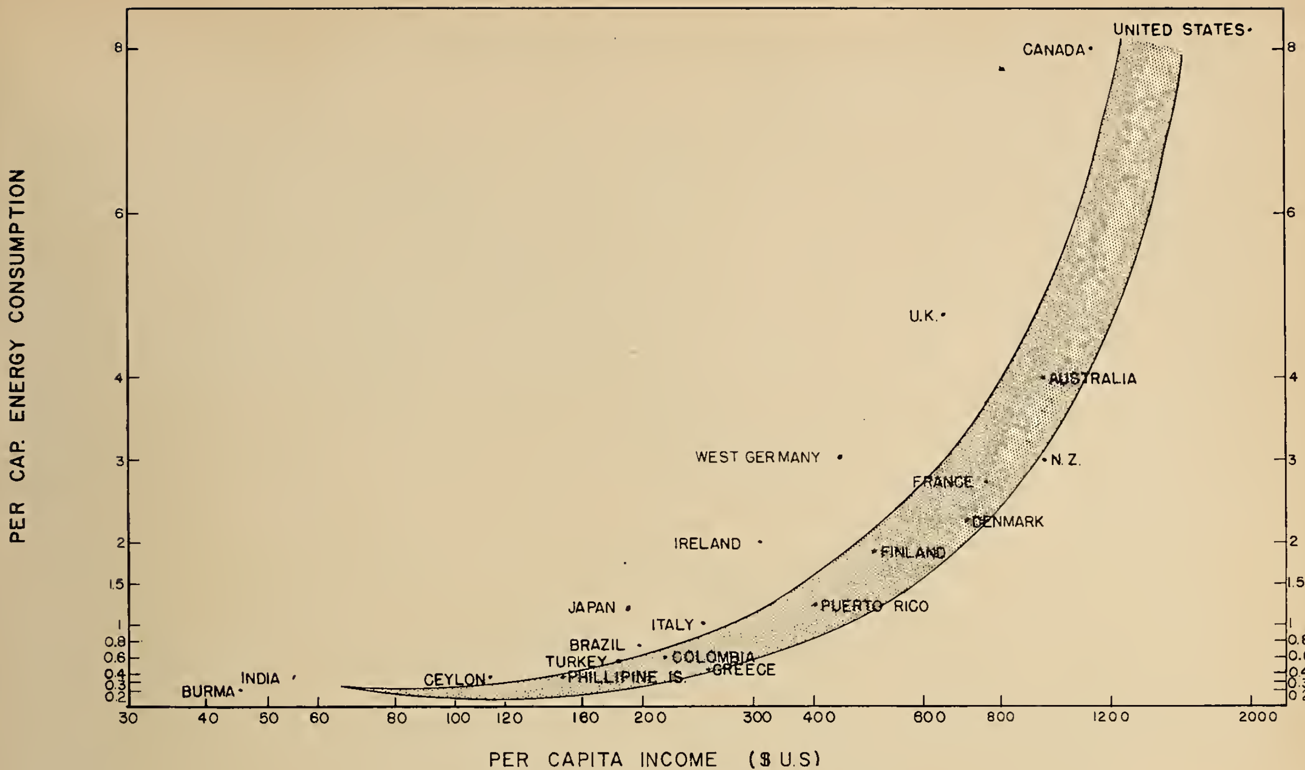


Fig. 4. Energy versus 1952 National Income.

and the railways will complete their dieselization by 1960. Marine operators are converting the remaining ships to oil and, except a few special cases, oil will be the marine fuel of 1980;

(c) Industrial fuels: Oil is presently used in those places where it can offer ease in automation, flexibility and the savings resulting in storing it in waste space or underground tanks and where the cost per million Btu. is lower than other fuels. These factors will increase its demand for many industrial purposes in the future;

(d) Petrochemical industry: Petroleum products will increase in demand as a raw material for the petrochemical, synthetic chemical and plastics industries.

Natural gas has become a major source of energy across Canada from British Columbia to Montreal and the Eastern townships. The construction of a network of transmission lines has brought the gas from the extensive fields in Alberta and Saskatchewan to British Columbia, Manitoba, Ontario and Quebec.

This energy source will largely confine its use to those fields where its extremely great adaptability to automation is a great factor, and where its cost per million Btu. is less than coal and oil.

Gas will capture the bulk of the domestic heatings field by 1965 as far east as Montreal. It will also make heavy inroads into the industrial space heating and process steam fields where there are enough transmission mains to warrant an uninterrupted flow and where the costs are lower than coal and oil. During the next five years, numerous plants will connect gas to their boilers to secure a firm supply of the material and then utilize it as a raw material while returning to coal or oil for fuel purposes. Even now natural gas is an important raw material in the chemical fields.

Natural gas is the fuel used to drive the thermal-electric plants in Alberta and Saskatchewan and the B.C. Electric Company is installing gas-fired boilers in their new steam plant near Vancouver. Several western companies are using this fuel to drive gas turbines, direct connected to electric generators.

No eastern power company is presently considering using gas as the principal fuel for a major power station, although several may connect it up as an off-peak load fuel. Of course, a station such as the Hydro's Richard H. Hearn or Long Branch would require the complete capacity of the Trans Canada Pipe Line and in addition would demand that a second pipe line of equal size be held in reserve.

Nuclear energy is not a commercial source of power in Canada at the present time although several units are in commercial operation in Great Britain and the United States. One semi-commercial 20,000 kw. nuclear powered electric unit is nearing completion and the Ontario Hydro and AECL are building a 200,000 kw. unit for commercial operation in 1965.

The Gordon Commission forecast that nuclear energy would furnish 5% of the nation's power requirements in 1975 and that by 1980 this figure would increase to 12.9%. However, the Ontario Hydro forecast that by 1975 they would use nuclear energy to produce 26% of Ontario's demands and

TABLE IX
Consumption of Petroleum by Uses
(percentage of total petroleum)

Use	*1928*	*1950*	*1955*	*1960*	*1980*
Aviation	—	1.5	2.5	2.5	2.6
Automotive	49.5	38.8	35.2	36.5	32.3
Railways	6.9	5.2	5.2	4.4	2.6
Marine	14.3	5.6	4.1	3.6	2.4
Residential	4.6	15.6	21.8	23.3	17.9
Industrial and Others	16.6	30.8	29.6	28.0	39.3
Fuel Conversion	8.1	2.5	1.7	1.7	2.9
Total	100.0	100.0	100.0	100.0	100.0

TABLE X

Consumption of Natural Gas in Canada

(millions of cu. ft.)

Using Sector	*1926*	*1950*	*1955*	*1980*
Residential and Commercial....................	13.0	40.4	74.1	795.2
Mining and Manufacturing......................	3.0	23.2	62.1	1076.9
Field and Wastes..............................	5.2	6.4	13.6	179.3
Total...	21.2	70.0	149.8	2059.3

TABLE XI

Consumption of Natural Gas in Canada

(percentage of total gas)

Using Sector	*1926*	*1950*	*1955*	*1980*
Residential and Commercial....................	61.4	58.6	49.5	38.6
Mining and Manufacturing......................	14.2	33.2	41.5	52.4
Field and Wastes..............................	24.4	8.2	9.0	9.0
Total...	100.0	100.0	100.0	100.0

that by 1980 this percentage would reach 31.75%. It is interesting to note in the Hydro's forecast that they figured nuclear energy would produce 133% as much power as would water power and 70.7% as much as the conventional thermal electric stations.

There is no question that nuclear energy is the ideal fuel to operate installations where the cost of transporting the fuel is extremely high and where the load factor will be above 75%.

On the other side of the picture, the nuclear power proponents have discussed the use of low-pressure saturated steam and before this source of energy can thoroughly compete with the conventional fuels some means of raising pressures and temperatures must be found or else all the advances in steam turbine design and power plant operation will be overlooked.

Generally economists consider firewood as the only energy source derived from our forest industries and report this a dwindling factor in modern industrial economy. They report the non-fuel uses of all the fossil fuels and trees are increasing with the growing industrialization of our civilization. Now let us see what results when we consider the non-fuel uses of Canada's forest products.

The conversion of wood into chemical pulp leaves about half the wood dissolved in the cooking liquors and disposed in various manners. That contained in the alkaline liquors is concentrated and burnt with the recovery of heat so that this would be added to our energy uses in addition to those normally shown. The acid liquors from the bisulphite processes are generally dumped into the streams to the annoyance of the conversationists. Several suggestions have been proposed to treat these liquors and recover saleable materials. Vanalin is being recovered at Thorold, alcohol at several mills and several lignin chemicals at others.

The production of alcohol might prove to be a valuable outlet for these wastes if costs including taxes could be reduced. Alcohol selling for ten cents a gallon, or even somewhat higher would have a definite market as fuel in several chemical fields. It has the advantage of burning with a non-smoky flame and containing few if any of the detrimental impurities which many of the petroleum and natural gases have. The large-scale production of cheap alcohol and allied compounds would force the present fuel distributors to seriously revise their marketing policies.

Conclusions

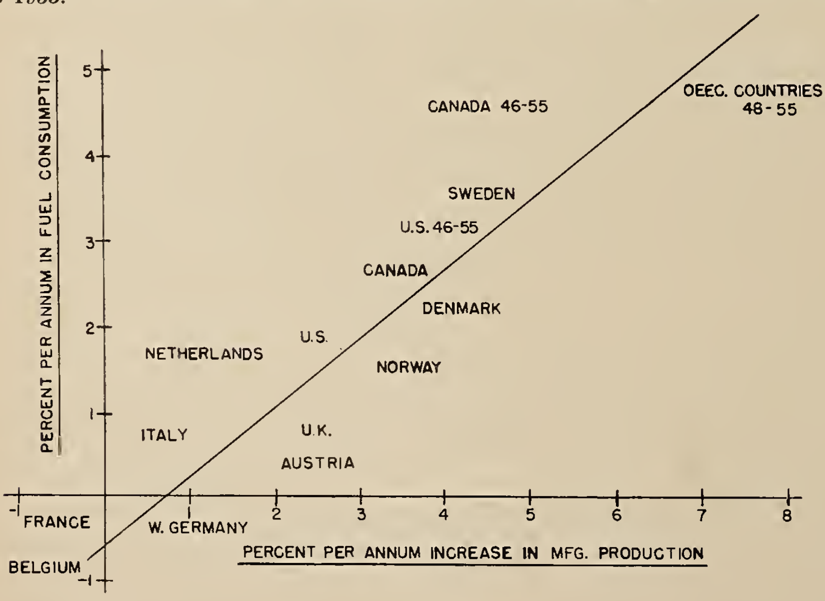
Canada's sources of energy during the next 20 years will be substantially the same as those presently used in increasing amounts although the percentages used will be substantially different.

Oil and natural gas will tend to replace coal and other solid fuels for domestic space heating and will furnish approximately 100% of the energy used for this purpose by 1965. During this period there will be a definite trend to the employment of radiant heat for space heating with increased efficient in the use of the energy. After 1965 electricity will begin to cut into this field, and by 1970 may attain as much as 40% of the space heating for domestic and commercial purposes.

In the large power plant field the 1980 load will be well distributed among water power, coal and nuclear energy; with natural gas and oil furnishing the most fuel in the prairie provinces. It must be remembered that in this field the demands for cooling water are enormous and at present this energy is lost. We expect that by 1980 methods of utilizing this waste heat for space heating will have reduced the losses considerably.

In addition direct connected gas turbines using gas, oil and powered coal will produce appreciable percentages of the power.

Fig. 5. Changes in primary fuel consumption and manufacturing production—1929 to 1955.



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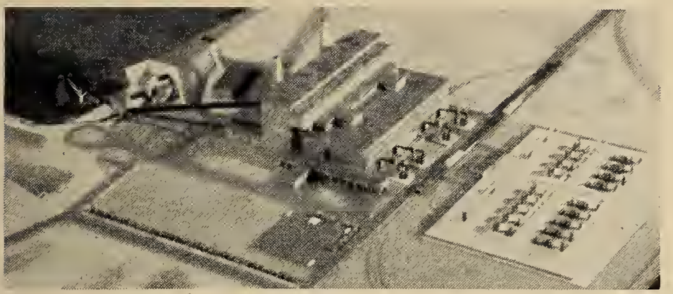
SASKATCHEWAN POWER'S BOUNDARY DAM GENERATING STATION



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The Boundary Dam Generating Station is a fairly conventional Thermal Power Station. Emphasis is given to two aspects which are of unusual interest in this instance, namely: (a) Problems of ensuring adequate cooling water supply; (b) Problems of mining, handling and burning Souris lignite. The total electrical load in Saskatchewan up to 1955 was increasing at over 20% per annum—an integrated provincial system with two large steam stations was then undertaken. Vast quantities of lignite in the south-eastern corner of the province led to the decision to build onelarge thermal plant there. Within a four mile radius of the chosen site there is 100 million tons of lignite which can be economically mined. The fuel has an average calorific value of only around 7,000 B.t.u/lb. and a moisture content, of over 30%, but can be delivered at about $1.30 per ton. An artificial lake formed by construction of an earth dam in the Long Creek valley near Estevan provides adequate cooling water storage and evaporative cooling surface. Mining, transporting, unloading, conveying, storing and burning of lignite is discussed with reference to the problems of high moisture content, and the danger of fires under certain conditions. The turbo-generator plant and other main equipment is then briefly described. Some of the difficulties encountered during construction and commissioning are covered and the paper concludes with a note on station cost.

BOUNDARY DAM Generating Station is a fairly conventional thermal power plant. We propose to give a brief general description of the first two units in the station and to bring out points of particular interest relative to the location in southern Saskatchewan, where problems of water supply and fuel supply are of particular importance.

The post-war growth of electric load in Saskatchewan has been around 20% per annum and up to 1955 was tending to exceed this figure. Saskatchewan Power Corporation decided to proceed with an integrated transmission and generation network covering most of the populated part of the province including provision of a large thermal plant in the southern part of the province in addition to the new Queen Elizabeth Generating Station at Saskatoon. Although the centres of load are around Saskatoon and Regina, extensive lignite fuel deposits in the south-east led to consideration of construction of a large station there.

Within a five mile radius of the chosen site for the generating station there are around 100 million tons of lignite which can be mined economically by the strip-mining process. The great problem, however, was the lack of large areas of water in this part of the province which could be used for cooling.

The generating costs were calculated to be lower than the costs of transportation of the fuel to sites where the water supply situation was more favourable.

Extensive studies were made of suitable sites for construction of a dam which would form an artificial lake adequate for the anticipated size of the station. The final site chosen was on Long Creek, about 4 miles south of Estevan. Long Creek is a tributary of the Souris River which drains a watershed extending to near Moose Jaw, enters North Dakota and returns across the border to join the Souris River at Estevan. Long Creek was very shallow and sometimes dry in the summer, but examination of the topography of the valley above the dam site showed that a lake of some 48,000 acre-feet could be impounded.

With the decision to build the station in the Estevan area studies were made of various sizes of units and steam conditions to meet the anticipated load growth and a decision was made to install initially two 66 Mw. units, with turbine stop-valve conditions 850 p.s.i., 900°F.

Design was started at the beginning of 1956 and construction work for the generating station started on the site in October of that year. The first unit at the station was commissioned in the spring of 1959 and the second unit early in 1960.

Water Supply Problems

A detailed study was carried out, in conjunction with the Water Resources Board of the Federal Department of Agriculture and the Prairie Farmers Rehabilitation Administration, of the run-off in various creeks and of suitable sites for construction of a dam. Once the present site was chosen as the most feasible a submission had to be made to the International Joint Commission for their approval.

The dam was designed by P.F.R.A. on behalf of Saskatchewan Power Corporation and is of earth construction with a clay seal extending deep into the bank on either side. The dam is approximately 1,000 ft. long and 80 ft. high above the original stream level. The dam was completed in time to catch the 1958 spring run-off and, by commissioning date, the 1959 spring run-off was also impounded. Neither of these were very heavy run-offs, but a lake was formed sufficient for the present installed capacity with about 9,000 acre-feet of water which gives 22 ft. submergence over the bell of the vertical-spindle C.W. pumps.

When the lake reaches normal full level, it will extend for some five miles south to the North Dakota boundary. The artificial lake has become quite a feature in the area with boating activity and increased wild life. Scrub was cleared from the valley for the length of the lake and very few homes, bridges or other structures were affected.

Once the position of the dam was known, considerable study took place on methods of locating the circulating water pumps relative to the dam. From the cost and layout points of view, a conventional pumphouse below the dam with horizontal-spindle pumps was desirable. However, the very large intakes necessary through the earth dam to get the water to the pumphouse were a major design problem due to possibilities of settlement of the dam, danger of leaks causing erosion, etc. A final decision was made to construct the pumphouse upstream of the dam.

A 4 ft. square concrete tunnel through the dam with a shut-off gate lets water through for downstream users. From the lake end of the tunnel a separate pipe supplies a Fire Pumphouse below the dam. This pipe may be used in the future to take water to the City of Estevan water plant so that the reservoir is directly connected to the city water system.

A 125 ft. wide concrete spillway in the bank adjacent to the dam has five 10 ft. high radial gates, 25 ft. long, electrically operated.

The main access road to the site goes across the top of the dam.

Some water is let down occasionally to augment the very limited supplies in the Souris River for Saskatchewan Power's existing Estevan Generating Station.

Cooling water is pumped from the pumphouse adjacent to the dam to the station and then back to the canal intake chamber with a syphon seal pit adjacent to the station building. A long canal returns the cooling water to a discharge structure on the bank of the valley some 11,000 ft. from the dam. The surface area for cooling purposes on the lake from the discharge point back to the intake will be around 300 acres at half of maximum level.

From the canal intake structure a 48 in. pipe for recirculation, with a shut-off gate, has been taken back to the main intake, so that some, or all, of the cooling water can be returned direct when winter conditions demand.

One interesting feature of the valley was the many small coal mining operations into the bank. Coal seams are exposed along the valley sides and numerous workings had been dug into the banks by small operators. These disused workings and air vents from them had to be avoided in construction near the valley.

The anticipated final size of the generating station is 332 Mw. with the present two 66 Mw. units followed by two 100 Mw. (or possibly 120 Mw.) units. For the four units a total quantity of 200,000 Imp. gal. per minute of cooling water would be required.

For design purposes the lake level has been assumed to range from a minimum of 1790 ft. to a maximum of 1840 ft. Present level is 1802 ft. Prairie level is 1850 ft.

The design water temperature was taken as 65°F., but due to the possibility of having to operate at low lake levels with a very limited cooling circuit, allowances were made for inlet temperatures up to 85°F. for auxiliary cooling purposes.

With a minimum working lake level of 1790 ft., a pumphouse had to be built with the pumpwell floor below that level and at a level to give the pumps adequate submergence. The floor of the pumphouse is at 1780 ft., while the motor floor is at 1846 ft., in order to be above the maximum possible flood level.

Fig. 1 shows the side elevation of the pumphouse.

The pumphouse is a reinforced concrete structure, built now to house pumps for the final four units and has a conventional pumphouse building on top of the concrete foundation. It includes a concrete intake culvert with a rough bar screen at the inlet, three screen wells and three separate pumpwells, each housing two vertical-spindle pumps. The structure is 100 ft. long, 60 ft wide, and is 66 ft. from the pumpwell floor to the motor floor.

With the vertical-spindle pumps necessary in such a design, considerable care was taken in ensuring that the dimensions of the pumpwell were suitable for correct suction conditions to the pumps. Model tests were carried out to ensure that the structure was properly dimensioned.

Gates have been provided to allow isolation of any screen well or pumpwell.

The three travelling water screens are each 10 ft. wide with 68 ft. centres. No differential level control was included. It was anticipated that once the initial spring run-off had cleared the sides of the valley there would be little trouble from further debris.

Three pumps have been installed for the present two units, with provision for three more when the station is completed with the additional two units.

The final scheme will have three pumps supplying Nos. 1 and 3 units and three pumps supplying Nos. 2 and 4 units. To keep down initial construction costs the first three pumps are supplying No. 1 unit and No. 2, through a temporary cross-connection of the supply mains.

The three pumps at present installed are vertical-spindle mixed-flow centrifugal pumps, each capable of pumping 33,300 Imp. g.p.m. with differential head of 95 ft. They are constant speed pumps, speed 590 r.p.m., with a 42 in. column 66 ft. long. They have below-floor discharges and are driven by 1250 hp. electric motors.

The three pumps now installed are capable of supplying all the water required by one 66 Mw. and one 100 Mw. unit with water at 65° and machines at full load.

Water temperature and lake level are appreciable additional variables in this instance, so that pump operating conditions vary considerably. With winter temperatures one pump will be adequate for the two 66 Mw. units now installed.

The 50 ft. variation from minimum to maximum lake level explains the high differential head of the C.W. pumps applicable at Boundary Dam compared with stations on lakeshore or river bank sites.

The C.W. pumphouse is 1600 ft. from the main building and all pump controls are arranged for remote operation from the Plant Control Room in the main building. Local controls are included for use where necessary.

The pumps are oil lubricated with the thrust bearing at the top of the motor. The 1250 hp. motors are water-cooled, but can be used with air cooling if required, the discharged air being used to warm the pumphouse.

Each pump has a 42 in. tilting disc check valve and an automatically-operated butterfly valve at the discharge. When starting a pump the equipment is arranged so that the pump starts first and runs up to speed before the butterfly valve starts to open. On stopping the equipment is arranged so that the butterfly valve is closed before the pump is tripped.

The three C.W. pump discharges are all connected into one 72 in. diam. steel main which supplies the water to the main buildings. In the future a second 72 in. main will connect the future pumps to Nos. 2 and 4 units.

The return pipes from each condenser lead individually into the canal intake structure. An effective syphon of about 10 ft. exists through the condenser part of the circuit.

The canal to the discharge at the far end of the lake was constructed by digging a wide trench and using the material excavated to form additional dykes at each side. Velocity through the canal with maximum flow is kept below 2 f.p.s.

Losses from the water system are those due to seepage, evaporation, water for ash handling (part of this is returned), boiler blowdown, water treatment effluents, etc.

Given reasonable fortune in non-occurrence of successive seasons of very low run-off in the Long Creek drainage basin, no difficulty should be encountered in keeping four units fully loaded.

Lignite Mining

A special feature of this project is the very large quantity of lignite fuel required, and methods used to handle and burn this. The fuel has an average calorific value of only 6,000 to 7,000 B.t.u. per lb., and has a very high moisture content of 30-35%. Fixed carbon is around 31%, volatile matter 25% and ash 10%.

The Corporation's plans for burning large quantities of lignite were co-ordinated with invitations to various coal mining companies to mine the coal under a direct contract.

The successful bidder is now operating under an 11-year contract to supply all the coal required by the station. A shovel with a 20 cu. yd. bucket is used for removing overburden with depths down to 70 ft. Seams now being worked are from 8 to 25 ft. below surface. The large shovel removes the overburden and piles it up on one side of the cut. When the top of the coal seam is exposed it is cleaned and the coal is then removed and loaded by smaller shovels at the bottom of the cut. The coal-mining shovels and excavators are electric driven. Explosive charges are used when necessary to break the coal. Run-of-mine coal is delivered direct to the station, the equipment there being designed to take lumps up to 4 ft. cube.

Forty-ton bottom dump trucks are being used at present. The intake equipment has been designed for the 50 ton trucks which will be used when deliveries are increased.

Eventual coal consumption will rise to more than 1.5 million tons per annum.

A large garage and maintenance shop with all the necessary services for the coal mining operation was constructed adjacent to the power station buildings.

Coal costs approximately $1.30 per ton delivered at the intake hopper.

Coal Handling

The coal handling equipment at present installed is designed to handle 400 tons per hour of run-of-mine coal to the bunkers, or to stockpile. Reclaimed coal from the stockpile is bulldozed into the main intake hoppers. The eventual capacity of the coal handling plant will be 800 tons per hour. This is based upon the coal being taken in on an 8 hr. shift in a normal five-day week. The stockpile is planned to be adequate to cover periods in fall and spring when trucks may be unable to move.

Trucks delivering coal from the mine are weighed on a 100 ton capacity scale and then bottom-unload into one of two 120 ton capacity intake hoppers. Breaker beams are set in the concrete hoppers to break large lumps and protect the reciprocating feeders which feed from the hoppers into the primary crushers. The primary crusher is a double-roll toothed type, 30 in. diam., 72 in. wide, which crushes up to 400 tons an hour of run-of-mine coal and breaks it down to minus 6 in.

Secondary crushers located in the crusher house reduce up to 400 tons per hour of minus 6 in. coal to minus ¾ in. A magnetic pulley above the secondary crusher removes tramp iron.

From the crusher house belt conveyors carry coal to the transfer house from which it can pass to the long conveyor to the bunkers, or to the stocking-out pile, or to a loading point for deliveries elsewhere. Sampling equipment is located within the transfer house.

The duplicate conveyor belts from the intake pocket to the transfer house are each 36 in. wide, travelling at 265 f.p.m. The main conveyor from the transfer house to the bunker room is a 48 in. wide belt, travelling at 265 f.p.m. In the future, for its final capacity of 800 tons an hour, this belt will run at 530 f.p.m.

A telescopic chute on the stocking-out conveyor retracts as the pile rises. A stockpile of 100,000 tons has been formed with no difficulties to date from fires.

A continuous weigher is fitted on the main belt to the bunkers with the instrument located in a coal-handling control room adjacent to the crusher house. In this control room all control functions are combined on a desk which has a mimic diagram of the complete system. The entire coal-handling plant is operable from the desk.

The tripper is motor-driven and controlled automatically by bunker level switches and limit switches. The coal-handling equipment is generally conventional in its components, but particular care had to be taken with this fuel to avoid hang-up in chutes feeding crushers and transfer points.

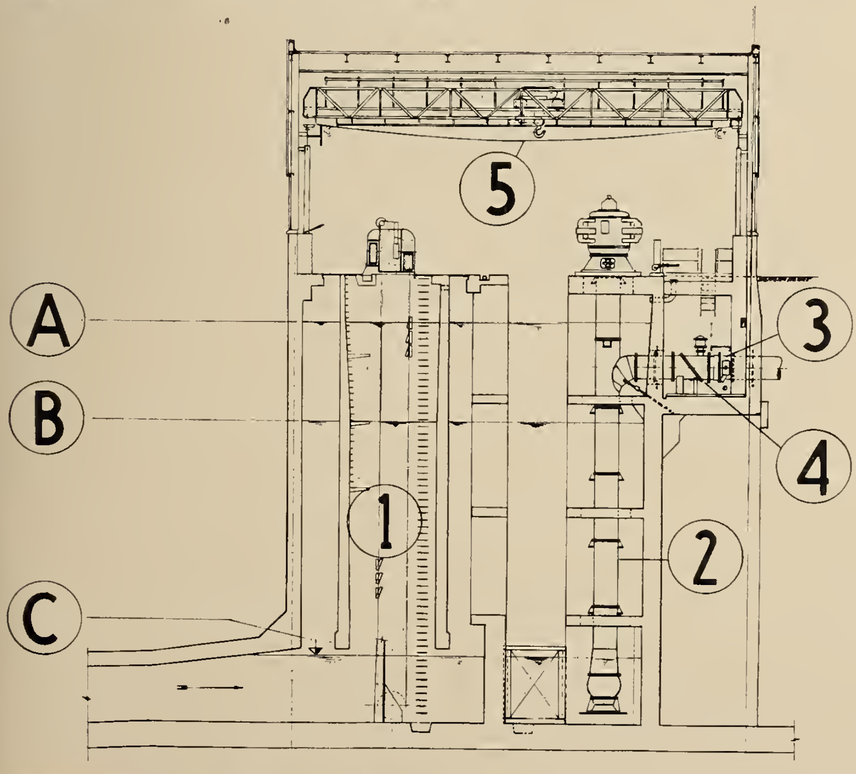
The coal-handling system is interlocked in sequence and an emergency safety stop system has been incorporated throughout.

Fig. 1. Side Elevation, C. W. Pumphouse

Legend:

A — high water level — 1840 ft. el.; B — normal water level — 1825 ft. el.;
C — low water level — 1790 ft. el.

(1) travelling water screens; (2) C. W. pumps; (3) 42 in. butterfly valve; (4) 42 in. tilting disc check valve; (5) 30 ton travelling crane.



Due to the high moisture content of the fuel all the coal-handling equipment is enclosed and heated.

The coal as delivered can vary considerably in surface moisture.

When the coal is dry, dust is a fire hazard. A spray system has been installed at all transfer points using, at the moment, service water. If adequate dust suppression is found impossible one of the proprietary wetting agents may be tried or cyclone type exhausters fitted on the bunkers.

In view of the known tendency of the fuel to hang-up, particular care was given to main bunker design. It was decided to install circular storage bunkers with stainless-clad double outlet cones. The cylindrical part of each bunker is 31 ft. in diameter. Each boiler has two bunkers with a total capacity per boiler of 1500 tons or 24 hr. capacity at full load.

Boilers

The two boilers now installed each are of maximum continuous rating 600,000 lb. per hr. with superheater outlet conditions 875 p.s.i., 915°F.

No. 1 Boiler is of radiant type with single drum, an economiser, and little boiler convection surface. Tangential tubes form an entirely water-cooled furnace of liberal dimensions which is front-fired by twelve burners.

Special attention was paid to the design of superheater surfaces to prevent bridging by the lignite ash. The first platens of tubes are widely spaced at 18 in. centres and the second bank at 9 in. centres. The superheater is of the self-draining type with considerable radiant heating to effect control of steam temperature at all loads. Steam temperature control is completed by attemporation by spraying feed-water into the intermediate attemporator headers. The spray water is used as a vernier control to effect the slight adjustment necessary.

Due to the low calorific value of the fuel, four very large mills are necessary for these units. On the boiler four EL 70 mills, each capable of crushing 38,000 lb. per hr. of lignite are installed. Full load is carried on three mills, except when the fuel is at the lowest specified calorific value of around 4,500 B.t.u. per lb.

Due to the high moisture content a very high air temperature for drying in the mills is required. The air temperature leaving the air heater at full load is 534°F and little or no use of tempering air is anticipated.

The disposition of heating surfaces on this boiler is as follows:—

Furnace	30,160 sq.ft.
Boiler	10,894 sq.ft.
Superheater	17,800 sq.ft.
Economizer	23,800 sq.ft.
Air Preheaters	69,000 sq.ft.

Each of the mills supplies three burners, each of which has an oil igniter adjacent to it. All functions for the igniters, impellers, coal/air gates, hot air gates, etc., are controlled remotely from the Plant Control Room.

Each boiler has two air heaters, two dust collectors, two F.D. fans and two I.D. fans.

An automatic sequential sootblower system uses steam for blowing. Particular care was taken in locating the blowers to ensure that fly-ash accumulations were not possible. Any horizontal surface causes progressive build-up of this fly-ash and all flues have been designed to avoid "ledges."

A water-impounded ash hopper collects bottom ash below the furnace.

The No. 2 boiler is of the same capacity and steam conditions, but is different in several features. It is corner-fired with sixteen burners of the tilting type, with steam temperature controlled by tilting the burners. Four bowl mills are included and again three of them are expected to carry full load. Each mill supplies one tier of four burners.

This unit has a large boiler convection section with a mud drum and has no economiser. The superheater in this case is of the pendant type in two stages. Similar design features for avoidance of fly-ash problems have been incorporated.

The furnace volume and dimensions generally are rather smaller than those on the No. 1 boiler. The fans and other auxiliaries are similar.

No. 2 oil is used for lighting-up purposes and for maintenance of flame when required on both units.

Turbo-Generators

Both turbo-generators have a continuous maximum and most economical rating of 66,000 kw. The turbines are two-cylinder 3600 r.p.m. machines with twin steam chests, a single flow HP cylinder and double flow LP cylinder.

The generator is cooled by hydrogen at 30 p.s.i. and has the exciter gear-driven from the main shaft.

The hydrogen coolers use distilled water which in turn is cooled in raw water heat exchangers.

The turbine and generator auxiliary equipment is quite typical.

The condenser is in two halves and of total surface 48,000 sq.ft. Each half of the condenser can be shut down for cleaning purposes while the set is on load.

Feed System

The feed heating system comprises five stages as follows: L.P. heater; Deaerating heater; and three high pressure heaters.

The extraction pump discharges through condensate oil coolers, through the main ejectors, through a drain cooler and the L.P. heater to the deaerator.

From the deaerator storage tank feedwater goes to the suction of the boiler feed pumps and then through the three H.P. heaters to the boilers. Final feed temperature at full load is 388°F.

Make-up to the system is controlled by the level in the deaerator storage tank. Controls are arranged to divert condensate through a 3-way valve after the ejectors, up to a high-level reserve feed tank when the deaerator level is high. When the deaerator level is low and make-up is required, the controls cause condensate to flow from the high-level storage tank to the condenser. Additional condensate is stored in low-level storage tanks which are arranged to automatically replenish the high-level tanks when required.

Each unit has three boiler feed pumps, each 50% capacity and electric motor driven. Each pump can be put on automatic standby and arranged to start automatically if the pressure from the running pump or pumps falls to a set value. The pumps are 8-stage and driven by 700 hp. motors. Controls for the feed pumps are in the Plant Control Room and on panels adjacent to the pumps.

Automatic Controls and Instrumentation

Air-operated controls are arranged to perform the following functions:

(a) Master steam pressure controls air flow to the mills and thus fuel flow. A mill proportioning controller for all four mills ensures that the total fuel flow is correct as called for by the master controller. Individual control stations with a bias feature allow the load per mill to be adjusted as required;

On the No. 1 mills a feeder controller automatically controls the feeder according to the primary air flow to the mill and the mill differential. On the No. 2 mills the signal from the master controller goes direct to the feeder and to the exhauster control damper;

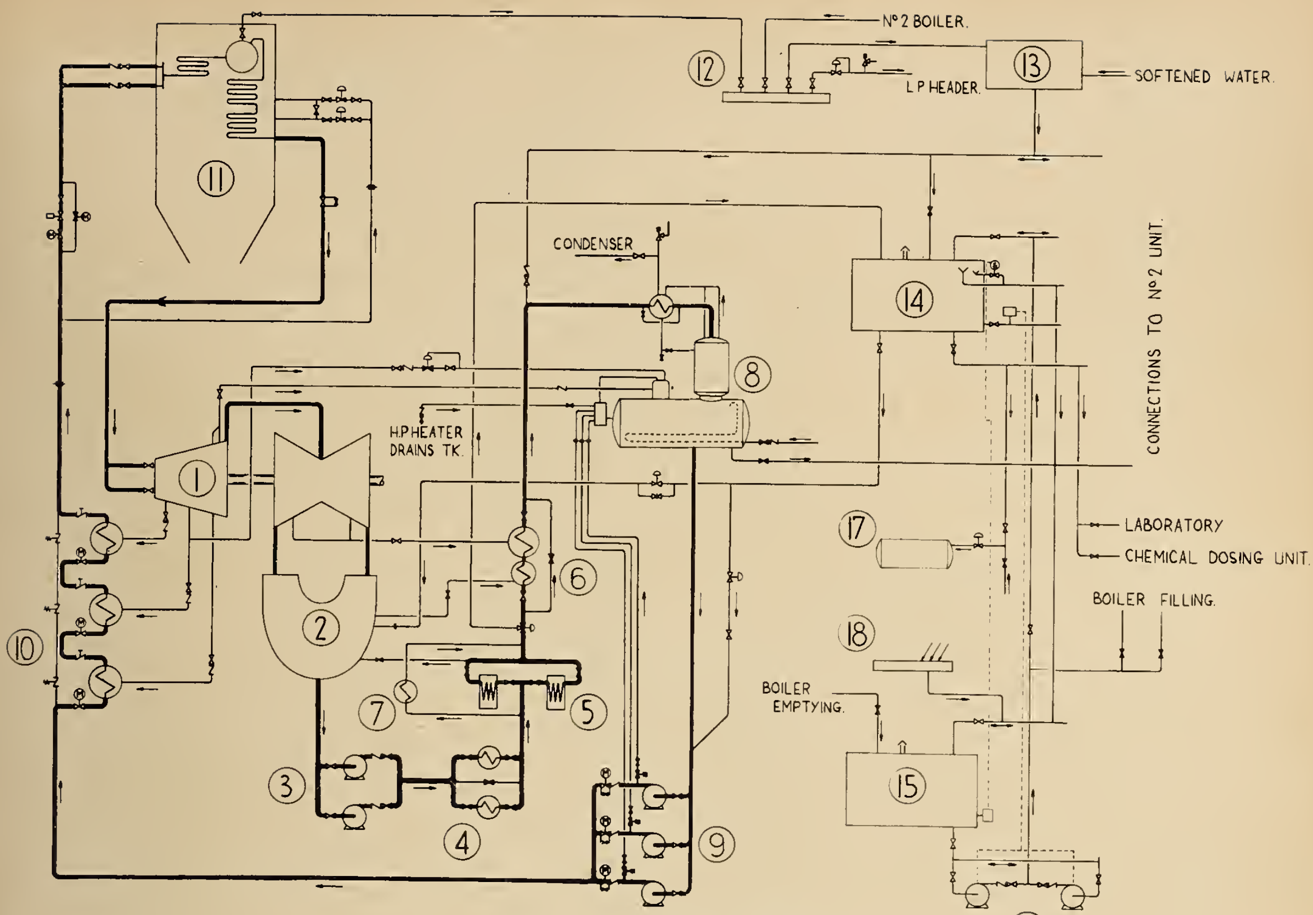


Fig. 2. Steam and Feed Diagram

Legend:

(1) 66Mw. turbo-generator; (2) condenser; (3) extraction pumps—2/100%; (4) lub. oil coolers; (5) air ejectors; (6) drains cooler and l.p. heater; (7) gland steam condenser; (8) deaerator; (9) boiler feed pumps — 3/50%; (10) hp. feed heaters; (11) 600,-000 lb./hr. boiler; (12) hp. steam header; (13) 35,000 lb./hr. evaporator; (14) high level reserve feed tank; (15) low level reserve feed tank; (16) reserve feed transfer pumps; (17) aux. boiler feed tank; (18) heating system condensate header.

(b) Combustion efficiency is controlled by a regulating steam flow/air flow ratio controller which controls the F.D. fan intake dampers.

A flue gas oxygen indicator recorder on the Plant Control Room panel informs the operator when adjustment of the steam flow/air flow ratio is necessary. An oxygen trim control on the panel allows direct adjustment of steam flow/air flow ratio;

(c) Furnace draft is controlled by I.D. fan speed and I.D. fan outlet dampers. Small fluctuations are corrected on the dampers and sustained load changes by automatic adjustment of the fluid couplings;

(d) Drum level is controlled by a three - element system comprising steam flow, feed flow and drum level transmitters which feed a computer relay designed to give an output signal which is governed by the relationship between the three variables. The output signal passes through an auto-manual station to the feedwater regulating valve;

(e) Steam temperature on No. 1 Boiler is controlled over the range where attemporation is necessary by control valves on the feedwater supply to each of two attemporator headers.

A casade system of control measures steam temperature at the attemporator outlets and at the secondary superheater outlet. The control point of the attemporator outlet controllers varies in accordance with final steam temperature so that attemporation responds quickly to changes.

All controls for normal operation of both units are combined in a single panel in the plant control room.

The room is located at operating floor level between the two units and between the turbine house and boiler house and is completely enclosed and air conditioned.

The main panel has five sections housing, from left to right:

1. No. 1 Boiler — Mill and P.A. Fan controls and instruments and burner pattern lights;

2. No. 1 Unit — Instruments and Controls for Boiler Draft, master pressure, megawatts, flue gas oxygen, final steam temperature, drum level, furnace pressure, steam flow/air flow, feedwater flow, boiler stop valves, I.D. and F.D. fans, air preheaters, boiler feed pumps, and for limiting maximum generator load;

3. A central section including, for both units:

Tank level gauges, condenser absolute pressure, circulating water pressure at condenser, fuel oil pressure and pump controls, heating steam pressure, dissolved oxygen recorder, conductivity recorder, air pressure and compessor pilot lights, controls for the remote C.W. pumps, controls for electric operation of the condenser inlet valves, synchronizing switches and electrical instruments relative to the station and unit switchboards.

4 & 5. Similar sections to Sections 1 & 2 for No. 2 Unit.

Annunciators for all important functions such as bearing tempera-

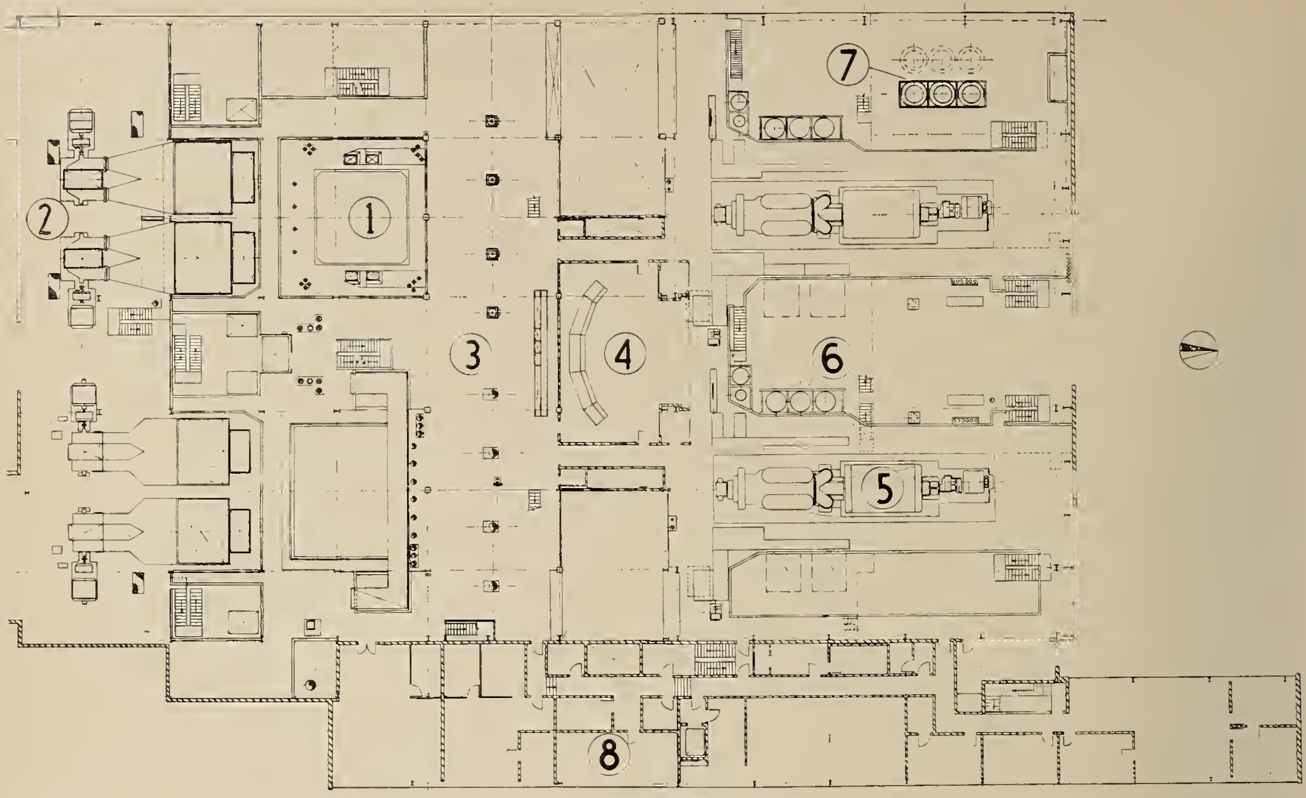


Fig. 3. Operating Floor Plan.

Legend:

(1) 600,000 p.p.h. steam generator; (2) induced draft fans; (3) bunker bay; (4) plant control room; (5) 66 Mw. turbine generators; (6) feed heaters; (7) evaporating plant; (8) administration, workshop and stores.

tures, trip of remote auxiliaries etc. are mounted on the panel. Where a remote station such as the C.W. pumphouse has several local annunciators a single common alarm on the plant control room panel is actuated when any one of the local alarms is actuated.

The main panel was designed to afford compact grouping of the various controls and instruments. The majority of the switches for routine operation are mounted on the protruding desk part of the panel. The protrusion was kept to 18 in. to ensure easy access to the equipment on the vertical part of the panel.

Each unit has a desk for the operator located in front of the main panel. Each desk includes a multipoint temperature indicator for routine checking of temperatures throughout the unit.

All variables are transmitted to the instruments within the plant control room and no high pressure or high temperature connections are brought in.

Direct pressure and level indicators for each boiler are visible outside protective windows at each side of the control room.

Loading of the generator is carried out from the system control room. A maximum load limiting device is included on the plant control room panel.

Each turbo-generator has a gauge board with all indicators for local operation together with indicators for the supervisory equipment. The turbine gauge boards are located adjacent to each turbine and outside the plant control room.

Inside the plant control room a further panel for each machine houses the recorders for the supervisory gear and a multipoint instrument for monitoring stator temperatures.

Adjacent to the plant control room in the bunker bay, panels have been located for sootblower equipment and ash handling equipment.

Electrical System

The electrical design of the station is based on the usual unit layout, Fig. 5 and 6 show simplified one-line diagrams of the power distribution system within the station and the connections in the switchyard.

Each 66 Mw., 0.85 p.f. 14.4 kv. hydrogen-cooled generator is connected directly, by means of isolated phase bus, to its 75 mva., 14.4/138 kv. generator transformer and 7.5 mva., 14.4/4.16 kv., Unit Transformer, the transformers being located outside the turbine house.

The generator transformers are oil-immersed forced-oil water cooled units. Each is equipped with on-load-tap-changing equipment. Two 100% oil pumps and coolers are provided per transformer, the oil pumps are arranged for automatic change-over in case of failure of the unit in service. The coolers are located indoors to facilitate maintenance.

On the high voltage side, the generator transformers are connected by overhead lines to the switchyard, which links them with the provincial power system.

The unit transformers are oil-immersed self-cooled units equipped with off-load tap changing gear. Their 4160 volt windings are connected, by means of cables, to the unit switchboards. Neutral grounding resistors are incorporated in the neutral connections to limit ground fault currents.

A 10 mva. 138/4.16 kv. oil-immersed self-cooled station transformer supplies power for starting-up and for station auxiliaries which are not directly associated with either Unit. This transformer, is equipped with on-load-tap-changing gear, and connected to the 138 kv. busbars in the switchyard and the 4160 volt station switchboard. A grounding resistor is incorporated in the neutral connection.

The 30/40 mva., 72/138 kv. auto-transformer provides means of interconnection between the 138 kv. switchyard and the 72 kv. provincial power system. A short 72 kv. transmission line to the switchyard of the Estevan generating station completes this link, the purpose of which is to provide for starting-up either of the two stations, to improve voltage conditions on the systems and to increase the stability of the systems. The auto-transformer is an oil-immersed self-cooled/forced-air-cooled unit, equipped with on-load-tap-changing gear.

Unit and Station Auxiliaries

Under normal operating conditions the generators supply their own power requirements for auxiliary equipment, through the Unit Switchboards connected to the Unit Transformers. The two unit switchboards, with the station switchboard connected between them, form a common line-up of switchgear located on the switchgear floor facing the Turbine House.

The station switchboard can be connected to either or both unit switchboards by means of bus-tie circuit breakers. Under normal operating conditions the bus-tie breakers are open, and are used only for starting-up or during emergency conditions. A synchronism check system prevents paralleling any two sources of supply at the 4160 v. voltage level when synchronism obtained at the 138 kv. voltage level is not maintained by the interconnections.

The unit and station switchboards are of the metal-clad type with 1200A and 2000A, 250 mva. electrically-operated air circuit breakers.

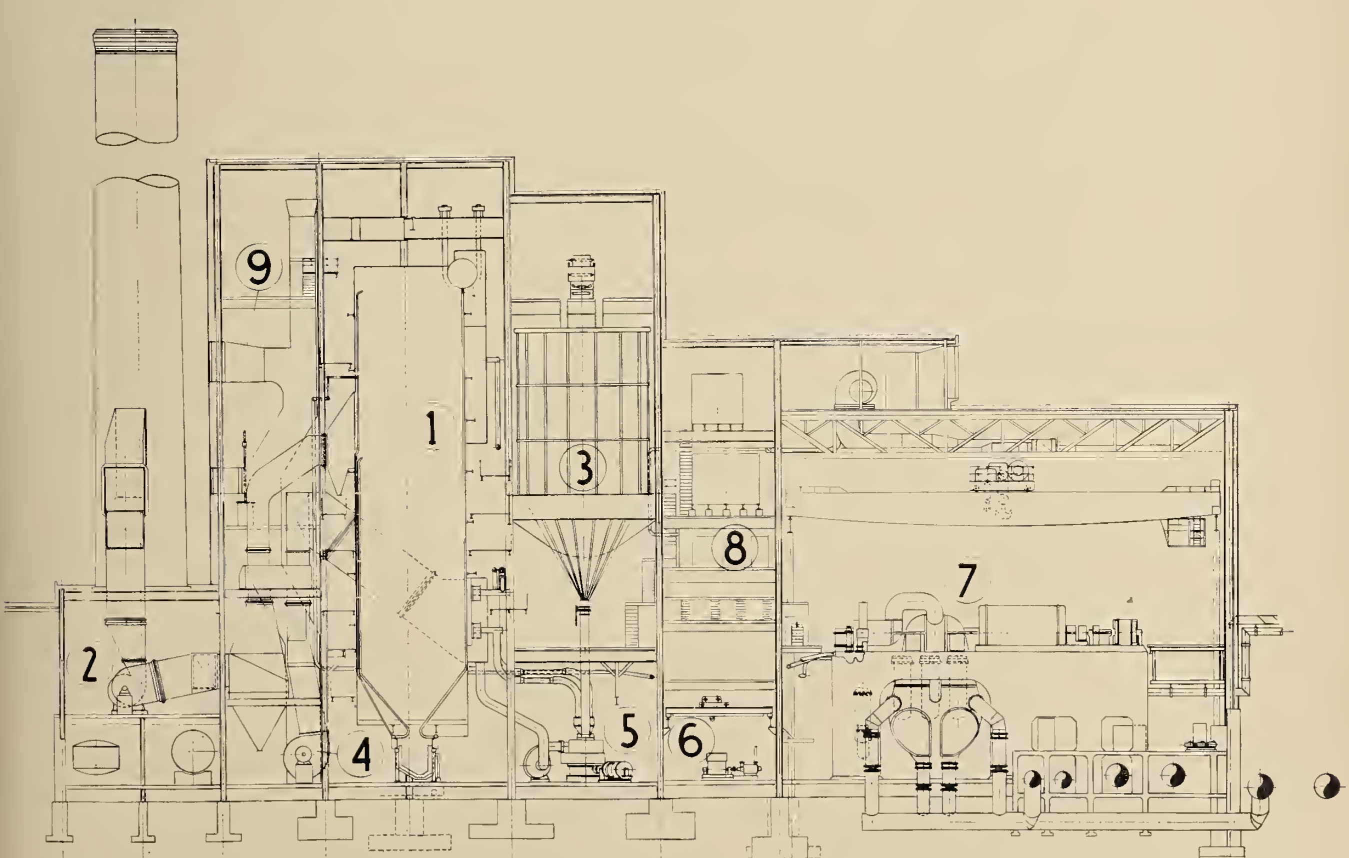
All electric motors driving unit auxiliary equipment which are over 100 hp. are supplied at 4,160 v. from the unit switchboards. This group includes the I.D. and F.D. fans, the mills and the boiler feed pumps. Also connected to each unit switchboard is one C.W. pump and one ash sluicing pump.

The station switchboard feeds the third C.W. pump, the coal handling plant and, through unit substations, all 480 v. auxiliary equipment which is common to both units. It also feeds unit substations which provide duplicate 480 v. supplies for unit auxiliaries and essential station auxiliaries.

The second voltage level of power distribution within the station is a 480 v. system originating at the unit substations also located on the switchgear floor. These are metal enclosed switchboards with dry type air-cooled transformers and manually operated, draw-out type air circuit breakers. Two of these, with 600 kva. transformers, are fed from the 4160 v. unit switchboards and supply turbine and boiler motor control centres. The remaining three (two 1000 kwa. and one 600 kva.), supplied from the 4160 v. station switchboard, feed motor control centres which control equipment common to both units and provide duplicate feeders to boiler turbine and essential station services

Fig. 4. Cross-section through the main building

Legend:
(1) 600,000 p.p.h. steam generator; (2) induced draft fans; (3) coal bunkers; (4) forced draft fans; (5) P.F. mills; (6) feed pumps; (7) 66 Mw. turbine generator; (8) switchgear; (9) combustion air intake ducts.



motor control centres. The following 480 v. services are typical for this group: lighting, air compressors, circulating water auxiliaries, water treatment plant, heating, ventilating, air conditioning, fire pump, system control building, workshop, etc.

Motor control centres located throughout the station at their respective load centres provide mounting space for all 480 v. combination magnetic starters used for the control of 480 v. motors. Small 115/230 v. panelboards also mounted in the motor control centres, supply small single phase auxiliary motors and solenoid valves.

Lighting

All lighting panelboards are supplied from identical single-phase 37.5 kva. 480-115/230 v. dry type transformers fed from the station services unit substations. The transformers are mounted in three-unit assemblies with common enclosures and are located on the switchgear floor, feeding strategically-located panelboards, equipped with molded case circuit breakers.

Color-corrected mercury vapour lamps are used for lighting the high-bay areas (turbine room, workshop, circulating water pumphouse). Fluorescent lighting is used extensively, typical areas being switchgear floor, plant control room, offices, feed pump aisle, boiler operating floor, coal handling plant operating areas. Incandescent lighting is also used, the system control room and boiler house galleries being typical areas.

Mercury vapour road lighting, controlled by solar clocks, has been used. Levels of illumination are in keeping with modern practice.

Particular attention has been paid to the lighting layout in the control rooms in order to avoid specular reflections from instruments and to provide a high level of illumination on the vertical surfaces of the switchboards.

D-C. System

Except for the internal telephones and the hydrogen alarm panel (which require a separate 50 v. d-c. supply) all station d-c. loads are supplied from a 125 v. switchboard located on the switchgear floor. The switchboard is connected to an 860 Ah lead-acid battery and two constant voltage regulated battery chargers. Normally one charger supplies the continuous d-c. load and float-charges the battery, the second one being used as a stand-by and for giving equalizing charges, when both chargers are used in parallel.

The main d-c. connected loads consist of control and indication or 4160 v. circuit breakers, emergency seal oil and lubricating pumps of both turbogenerators and the emergency lighting.

A separate 125 v. battery, chargers and distribution board are used for the d-c. loads associated with the switchyard.

Cabling

All 4160 v. cables are paper insulated, mass-impregnated non-darining, lead covered type. Single conductor cables have an overall neoprene jacket.

480 v. cables are either butyl rubber insulated, neoprene jacketed, or mineral insulated copper sheathed type, depending on the location of the cable run.

Thermocouple extension connections are made with mineral insulated steel sheathed cable with iron/constantan conductors. Within the station the cables are routed on cable trays. Cables outside the building are in fibre duct banks encased in concrete.

Communications

A 100 line private automatic exchange is installed to provide for direct communication between operating personnel and for administrative personnel in the main plant building and outbuildings. The system features executive right-of-way, conference calls and direct dialling to the plant control room for a fire alarm.

A staff locating system is provided for in the initial installation of the PAX, and will either be accomplished by a Morse code calling system.

Switchyard

The switchyard arrangement is based on the so-called breaker-and-one-half scheme with two main buses. (Fig. 6 is a simplified one-line diagram of connections). It provides two circuit breakers for each feeder and affords much flexibility and reliability. Normally both main busses are energized and all circuit breakers closed. However, either bus, or any circuit breaker can be removed from service without interrupting service or disruption of protection.

The 138 kv. circuit breakers are rated 1200 amp., 3500 mva. and are of air-blast type. Compressed air is supplied by two 30 c.f.m. 900 p.s.i.g. compressors through dryers, a storage bottle system, filters and reducing valves to a dual radial air supply distribution system in the switchyard, with air to the breakers at 350 p.s.i.g.

The disconnecting switches are of the group-operated 3-pole, vertical break type. The feeder and generator switches are motor operated.

The connections in the switchyard are made with either copper tube (for low level buses) or stranded copper conductor (high level buses).

Insulation coordination is based on apparatus impulse level of 650 kv., which is the full level for 138 kv. service voltage. 80% lightning arresters were used for the solidly grounded system.

An interesting feature of the switchyard is the 18.5 mvar. shunt reactor connected to the 138 kv. busbars. Its purpose is to compensate for the large charging current of the long transmission lines and thus improve the stability of the system.

A 72 kv. feeder shown in Fig. 6 supplies the 2,500 kva. coal mining substation. 4,160 v. feeders from this substation, located near the stripping operations, supply the draglines and shovels.

5 kv. trailing cables, portable switchhouses and portable substations provide means of power distribution in the coal mining areas.

The system control building, located between the turbine house and the switchyard, houses all equipment for the control, indication and protection of the turbo generators, main transformers and switchyard equipment.

Water Treatment

Make-up water for the units is taken from the C.W. supply mains to water treatment equipment located in an annex to the boiler house. The equipment comprises a clarifier for removal of dissolved and suspended solids, followed by sand bed filters and a zeolite softener. Softened water is pumped to a storage tank at high level which then feeds a central evaporator plant.

The central evaporator plant takes softened water and distills it for both units. The plant has a capacity of 35,000 lb. per hr. of distillate and uses about 1 lb. of steam to produce 6-7 lb. of distillate. High pressure saturated steam from the boiler drums is used for the inlet nozzle of the evaporator plant, which is of the thermo-compressor type.

The make-up enters the feed system at the inlet to the deaerating heater for each unit.

Miscellaneous Services

For general services such as cooling bearings, compressor aftercoolers, etc., filtered lake water is used. Raw water from the C.W. supply mains is pumped through sand bed filters to a high level tank which feeds the various services around the station.

A fire-protection system has been installed with a small fire pumphouse located below the dam in the valley where the most assured source of water is available. The pressure system has automatic starting of an electric pump followed by a diesel pump if the electric one does not start. An external ring main supplies hydrants at various key locations and an internal ring main supplies the various areas needing protection. Turbine oil equipment, seal oil equipment, generator and unit transformers, etc., are protected by deluge type equipment. Coal handling plant is protected throughout by a sprinkler system.

Two auxiliary boilers each of 10,000 lb. per hr. capacity, fired by No. 2 oil, were installed early in the project for heating during construction and for availability of steam if necessary for emergency heating and re-starting. A steam heating system for the plant and out-buildings uses 100 p.s.i. steam which normally is taken from the main boiler drums.

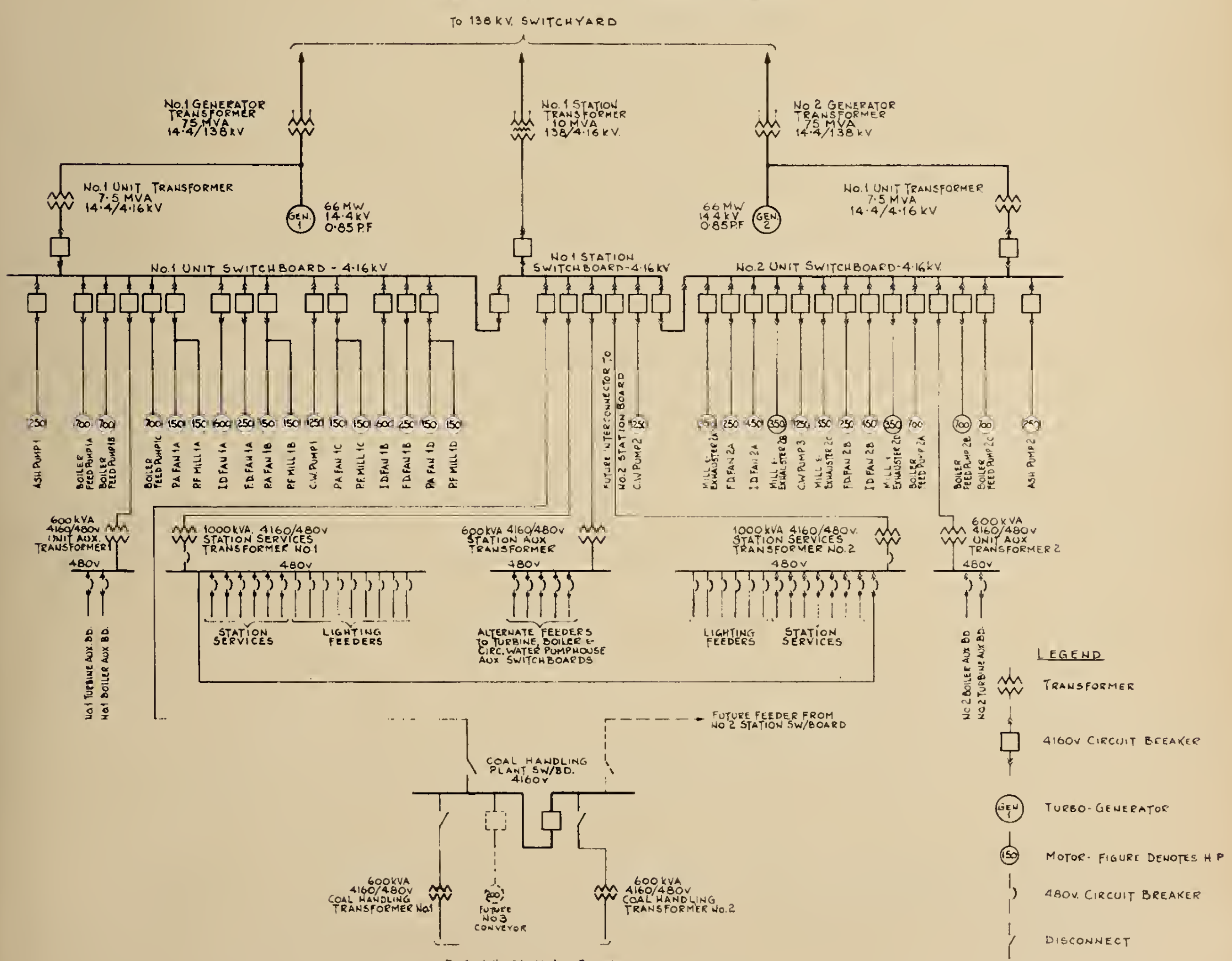
The main building ventilation system includes heating of the incoming air in winter and is independent of the combustion air intake system. Combustion air is taken separately through heating coils direct to the F.D. fans. Ventilation air passes through its own plenum room and into the building.

Ash handling equipment for the station required careful consideration due to trouble experienced by Saskatchewan Power Corporation at other plants with fly-ash from lignite fuel. The fly-ash has the characteristics and behaviour of cement and has been found very difficult to load into vehicles by dustless unloaders. Bottom ash is collected in water-impounded hoppers under the boilers and pumped to ash ponds. Fly-ash is withdrawn dry by a vacuum system operated by a hydraulic jet. The fly-ash plus water from the hydraulic jet flows by gravity through the same discharge line to the ash ponds.

As disposal of the ash is a problem in the area and as much water as possible must be returned to the lake, it was decided to build large lagoons or ponds adjacent to the coal pile and to drain these into a further settling pond from which clean water flows into the C.W. canal and thence back to the lake. Each pond is capable of storing 6 to 8 months' capacity of the two-unit station at full load. Each boiler produces about 6 tons an hour of ash at full load. Ash in the ponds will be removed by clamshell once a year.

Cranes in the plant are conventional. Consideration was given initially to installation of a crane of capacity sufficient to handle the generator rotor in the turbine house rather than one capable of lifting the heaviest load, the stator. A 50

Fig. 5. Station A. C. one-line diagram



ton crane would then be satisfactory instead of a 125 ton. In other stations it has been found more economical to provide special lifting gear for the few occasions when a stator has to be handled and to size the turbine house crane only for normal weights to be handled during maintenance of the machines. In this case a 125 ton turbine house crane has been installed.

Office accommodation including a general office, superintendent's office, workshop, laboratory, instrument shop, etc., are housed in an annex adjacent to and attached to the main building.

A garage building adjacent to the station is used for servicing corporation vehicles associated with the station and in general use in the Estevan area.

Layout and Building Finish

The general layout of the station is quite typical except for the circular bunkers.

Studies of foundation conditions showed the existence of several coal seams which played a part in dictating footing levels. Some trouble was experienced during construction of foundations due to coal seams dipping and rising from one part of the site to another. A final compromise of layout and foundation conditions was made whereby the basement was 16 ft. below prairie level. This allowed the footings to rest on a bed of shale. Individual footings for each column were used and no piles were necessary.

The general positioning of the buildings relative to the area was determined by the location of the dam, which dictated the lay-out of the C.W. system, and the location of the coal mines which dictated the direction from which the incoming fuel would come. There is ample space for further extension beyond four units provided the water supply allows such expansion.

The buildings are of insulated aluminum siding with metal deck roofs.

The single chimney for the two units is of radial brick construction located on the roof of the I.D. fan annex at the rear of the boiler house.

Construction

Some of the construction problems in the area were unusual. Winter conditions are, of course, very severe for erection of steel work and external work on concrete work and buildings. Some difficulties were experienced with early concrete work under winter conditions. Construction proceeded non-stop however, from commencement in October 1956 to completion early in 1958. Difficulty was experienced in obtaining good-quality aggregate for concrete construction within reasonable distance of the site. Prior to completion of the dam, a spring provided abundant water for concrete.

Cost

The approximate total cost of the present installation housing two units is $22 million or $167 per kilowatt of installed capacity. This sum does not include the cost of the dam itself nor the coal rights, nor the coal mining equipment contract. It does include, however, the high voltage switchyard and considerable civil costs associated with the future units, particularly for the C.W. system. The anticipated final cost for the four-unit station is $136 per kilowatt.

Operation

Operation to date on No. 1 Unit has been normal except for the following points of interest.

Trouble was experienced after a few months' operation with the C.W. system. Severe water hammer occurred when one of the vertical-spindle C.W. pumps was stopped and damage was caused to cast iron components of the system. A detailed study of the hydraulics of the system took place and the conclusion reached that the trouble was due to separation and rejoining of the water column near the condenser due to the rapid decay in pressure when a pump is tripped. Additional vacuum-breaking valves were added at key locations and no further trouble has been experienced.

Some initial troubles were anticipated with the coal-handling equipment due to the sticky nature of the fuel. After some minor troubles and minor adjustments to the components, however, this works satisfactorily.

One pre-commissioning worry was the known tendency of the fuel to cause fly-ash build-up in the boiler and particularly to cause of clogging of the mechanical dust collectors.

Experience to date, however, has been reassuring, with the boiler surfaces remaining clean and no trouble experienced at the dust collectors.

The ash system has worked satisfactorily to date with no trouble experienced handling the fly-ash.

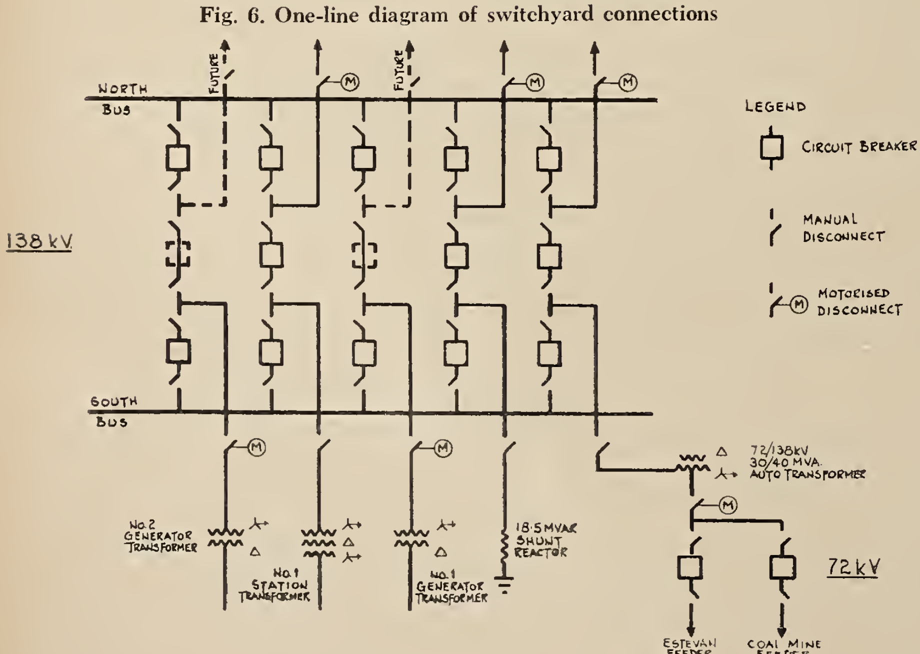
The pulverisers required several field adjustments to suit them to the unusual characteristics of the lignite fuel.

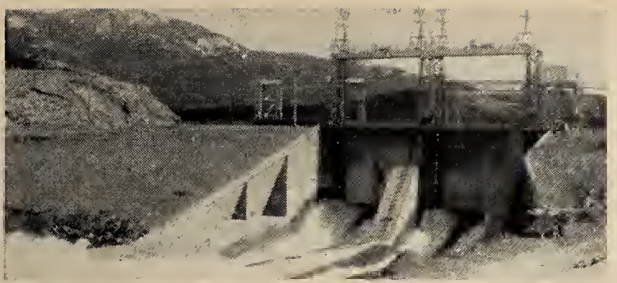
Conclusion

The brief account above has, of necessity, been only superficial relative to the equipment installed at this station. It is felt, however, that to give a vast list of design data would be of less interest and give less scope for discussion than a brief summary of some of the highlights.

Our thanks are extended to Saskatchewan Power Corporation for permission to issue this description.

Fig. 6. One-line diagram of switchyard connections





WHITEHORSE RAPIDS POWER DEVELOPMENT

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

This development is located about one mile upstream from the City of Whitehorse on the Yukon River, where an ancient lava flow created the Whitehorse Rapids. The turbulent waters of these rapids, together with those of Miles Canyon some three miles upstream, were the major obstacles to water transport on the "Trail of 98", and originally a wooden railroad was built to portage this dangerous reach of the river. Remnants of this railroad were still in evidence when the development was started. Downstream from the Whitehorse Rapids the river is navigable to the ocean, and with the coming of the gold rush Whitehorse became the head of navigation. It was joined to the Pacific Coast by rail with the completion in 1902 of the White Pass and Yukon Route Railway to Skagway, Alaska. The next major land access route into the Yukon came into being during World War II, when the 1,500 mile Alaska Highway was built from Dawson Creek, B.C. to Fairbanks, Alaska. Whitehorse is at milepost 917 on this road.

THIS PARTICULAR area of the Yukon is semi-arid, with an average annual precipitation of about 10½ in. Although Whitehorse is only 100 miles from the Pacific Ocean, the climate is mainly continental, with cold winters and warm, dry summers. The St. Elias and Coast Ranges act as a barrier to coastal weather entering the Yukon. The Whitehorse area is generally warmer than the rest of the Yukon Territory because of the milder Pacific air masses which move in through the White Pass (maximum elevation 2,915). Snow has been observed in every month of the year in this area, although it is a rare occurrence in the months of June, July, and August. The mean annual temperature at Whitehorse is 30.8°F. The maximum and minimum temperatures recorded during the construction of the Whitehorse Rapids Power Development were 85°F and —47°F.

Site Selection

The hydro plant was built to serve the growing power requirements of the Whitehorse area. It will provide for the load growth of the Yukon Electric Company, Ltd., and will supply the requirements of the Department of National Defence and of the new hospital of the Department of Health and Welfare. Some 5000 kw. of diesel plant capacity, operated by the Department of National Defence and Yukon Electric Company, was retired when the new hydro plant came into operation.

Three hydro sites were considered by the Northern Canada Power Commission in the initial investigation in 1955: the Whitehorse Rapids, the outlet of Kusawa Lake, and the outlet of Aishihik Lake. All three sites were within 75 miles of Whitehorse. Some consideration was also given to a steam plant to burn coal from Carmacks, about 100 miles north of Whitehorse. The Whitehorse Rapids site was found best suited to the development of the region. It offered the prospect of meeting present load requirements at reasonable cost, and could be expanded to meet future growth. After a study of load requirements and water available, it was decided to install two 7,500 hp. units in the initial development, and to leave space for the addition of a third 7,500 hp. unit in the future.

Hydrology

The Whitehorse Rapids Hydro-Electric Development utilizes water from 7,500 sq. miles of drainage area comprising the headwaters of the Yukon River (formerly called the Lewes River). Most of this drainage area consists of high mountainous country lying to the east of the Coast Range and gives rise to many small streams and several large lakes. This area contains some of the largest ice-fields in North America. The principal lakes in the upper watershed (Bennet, Tutshi, Atlin, Tagish and Marsh) have a combined surface area of approximately 430 sq. miles, or about 6% of the total drainage area. The Yukon River proper comes into being at the outlet of Marsh Lake, and the power site is about 17 miles downstream from this point.

River stage and discharge measurements of the Yukon River have been made at Whitehorse for more than 50 years, and were available as follows:

(a) Miscellaneous discharge measurements—1915;

(b) River gauge heights, May to October—1902 to 1928;

(c) River gauge heights, continuous —1928 to 1943;

(d) Continuous daily discharge in c.f.s.—October 1943 to September 1954.

A hydrograph of mean monthly discharge derived from the daily flow data for the 11 years October 1943 to September 1954 is given in Fig. 3. An examination of this hydrograph will show that the Yukon River is extremely well regulated by the large lakes in the upstream reaches, and the annual flow patterns are remarkably uniform. Conversion of the earlier gauge records to flow indicates that this uniformity of flow has existed throughout the 52 years for which data were available.

As a further illustration of the uniformity of the annual flow distribution, flood peaks in excess of 20,000 c.f.s. have occurred twice since 1943 and it is estimated that this peak was exceeded six times between 1902 and 1943. However, the highest peak discharge recorded is only 22,800 c.f.s. on August 9th and 10th 1953.

In order to determine what the maximum capability of the drainage area might be, it was decided to make flood routing analyses of hypothetical floods. The maximum recorded precipitation in the watershed area is 4 in. Assuming:

(1) that this entire rainfall could occur in a single storm;

(2) that 100% run off would take place in a period of about two weeks;

(3) that the instantaneous peak flow would be equivalent to 30 c.f.s. per sq. mile of drainage area; and

(4) that a base flow, originating from snow melt, of 15,000 c.f.s. existed in the river at Whitehorse at the time the storm began;

hypothetical flood hydrographs were derived.

Floods were assumed as originating on:

(a) the entire drainage area;

(b) the lower portions of the drainage area.

It was found that the flood storage on the lakes is so great that the calculated peak flow in the river would not exceed 30,000 c.f.s. even under these conditions. A flood of this magnitude can be discharged through either one of the two main sluice gates provided in the dam—in addition, there is a regulating gate of 3,200 c.f.s. capacity for fine adjustments of the discharge.

An installation of two 7,500 hp. units was desired to supply the electrical load in Whitehorse at an average winter load-factor of 65%. Examination of the water records shows that the flow has seldom, if ever, fallen below 1,600 c.f.s. A net head of 61 ft. would therefore be sufficient to supply the required power with 1,600 c.f.s. through the plant. It could be developed by raising the water level at the head of the Whitehorse Rapids to elevation 2141 and leading the water along the left bank of the river in a canal and penstocks to a powerhouse discharging at a minimum tailwater level of 2078. Two feet of pondage has been anticipated on the forebay to meet daily load fluctuations. Provision has also been made in the powerhouse for the future addition of a third 7,500 hp. unit, to bring the total installation to 22,500 turbine horsepower. Addition of this unit would require a minimum winter flow of 2,400 c.f.s. The large area of the upstream lakes will permit a relatively economical development of the storage necessary to guarantee this flow. For example, a useful storage range of only three feet on Marsh Lake is estimated to be adequate to provide this additional regulation.

General

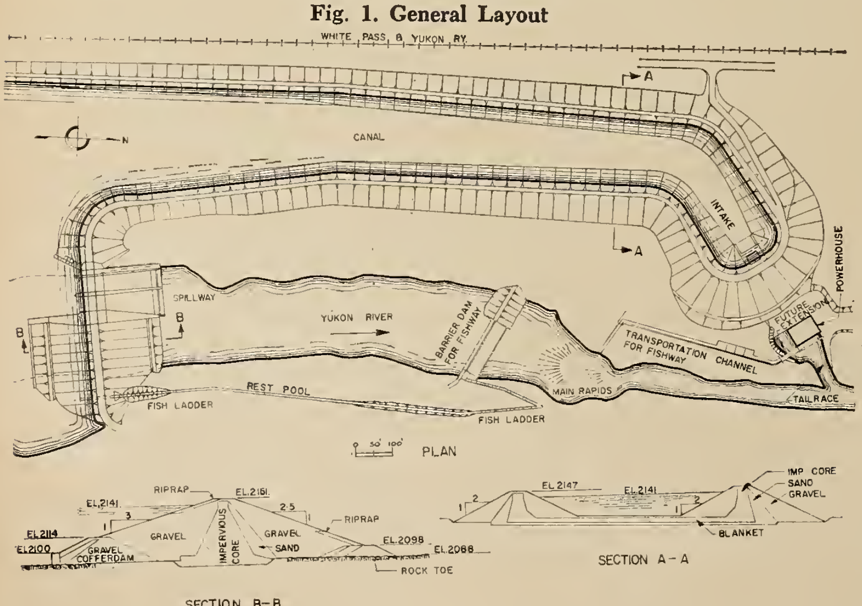
The decision to proceed with this development was made in August 1956. The first unit generated power for the local system on November 15, 1958.

The general layout of the development is shown in Fig. 1, and consists of the following structures: main dam, spillway, canal, intake, penstocks and powerhouse. The fishway facilities consist of a collection system and transportation channel at the powerhouse, a barrier dam, a fish ladder, and a concrete box culvert through the dam. A two transformer step-up substation is located adjacent to the powerhouse.

River Diversion

The Whitehorse Rapids gorge has a drop of some 12 ft. in about 1,500 ft., hence violent flow conditions exist at all river stages. In winter, prior to the construction of the power development, the Miles Canyon to Whitehorse Rapids reach of the Yukon River produced frazil ice for some 4 to 6 weeks before the rapids froze over. The ice pack, under severe winter temperatures, inched up the rapids creating, at the dam site, backwater conditions raising the water level some eight to ten feet higher than that of peak summer flows.

Fig. 1. General Layout



A major problem on the project was the diversion of the river during the various construction stages. Fig. 4 shows cofferdam stages 1 and 2 for the spillway structure and the main dam, and cofferdam stages 3 and 4 for the barrier dam. All diversions were carried out within the confines of the existing gorge.

Generally, rockfilled timber cribs were used in the cofferdams, because of space limitations and swift water. The contractor developed the timber crib shown in Fig. 4, Section A-A, for the longitudinal section of the cofferdam, which was exposed to high velocity water in the first stage of the construction. The two interior compartments were rock filled, leaving a 2 ft. void adjacent to the exterior sheathing. Two feet of the concrete was placed under water at the bottom of this void to effectively seal the contact of the sheathing with the bedrock. The remaining space was then rockfilled to complete the crib. Water velocities in the narrowed section of the river were estimated to be about 20 f.p.s. at the high summer stage in 1957.

Work on the first stage cofferdam was started in January 1957. Timber cribs were pushed out some 150 ft. in the river, leaving a width of about 130 ft. to pass the peak flow of the following summer. The water level rose some 10 ft. by the end of January as a result of backwater conditions caused by the ice pack gradually moving up the gorge. Timber cribs therefore had to be launched in water up to 16 ft. deep. The contractor used discarded tractor tracks as weights on the cribs to overcome the buoyancy problem in the deep water. The weights were also very helpful in placing timber cribs in fast water. Wakefield piling, made up on the site, and 4 in. tongue and groove were used for the exterior sheathing of the timber cribs. A buffer crib was put in at the upstream corner to protect the sheathing from the ice run. The first stage cofferdam was completed in early May. Two 10 in. diesel pumps and two 6 in. gas pumps handled the leakage inside this cofferdam, caused by a maximum head of 18 ft. of water against the upstream cribs. The first stage cofferdam was removed in late 1957.

The low height of the second stage upstream cofferdam was made possible by leaving unpoured, in the 1957 phase of the spillway construction, the top 16 ft. of the concrete ogees in the main sluices. The second stage cofferdam is shown in Section

B-B of Fig. 1. An 8 ft. wide, rock-filled timber crib built to elevation 2100 was used to divert the river through the sluices at the low stage in April 1958. Behind this low crib, a gravel dyke was built to elevation 2114, sufficient to handle the expected peak flow in the following summer. This upstream cofferdam became an integral part of the main dam. The rock toe of the main dam, sealed with gravel and silt on the inside, was used as the downstream cofferdam. This silt was removed and replaced with pervious gravel, after the core section of the main dam rose above the water level adjacent to the rock toe. The concrete transition wall at the east side of the spillway completed the enclosure.

The final steps in the unwatering of the main dam spillway required the closure of one 40 ft. sluice opening to complete the ogee and flip bucket concrete, while the river was passed in the other 40 ft. opening. The second sluice was then closed, and the river allowed to rise over the previously completed ogee. The sluice gate stop logs were used for these operations in construction checks located upstream of the ogees. These steel logs were handled by a 20 ton hoist mounted on a monorail. Arrangements were made in the gate superstructure to install the monorail temporarily over the construction checks. The logs are normally lowered by gravity, and are intended to be placed in still water, with the gate closed. In this case, however, they had to be placed in high velocity water, and there was danger that the friction between the logs and the guides would prevent the former reaching the bottom of the opening. It was thus imperative that the closure be made at as low a river stage as possible. This was particularly true when closing the second sluice, as the flow had to be diverted over the completed ogee of the first sluice. In order to obtain a sufficiently low stage of the river for this operation, the small storage dam at the outlet of Marsh Lake was used to regulate the flow.

The Lewes River dam at the outlet of Marsh Lake is a pile bent structure with 7 flash-board sluices and 21 gate openings. It was normally left fully open during the summer, and was closed in late fall, after the natural river flow dropped to about 8,000 c.f.s., leaving a residual flow of about 4,000 c.f.s. in the river. Water thus stored on Marsh Lake by this dam during the winter was released in quantity in the early spring.

A test closure on the Lewes River dam in early October 1957, with the river flow at 17,500 c.f.s., indicated that the closure of the dam would not be effective, unless the natural outflow from Marsh Lake was less than 15,000 c.f.s., otherwise, the gates of the control dam would be overtopped.

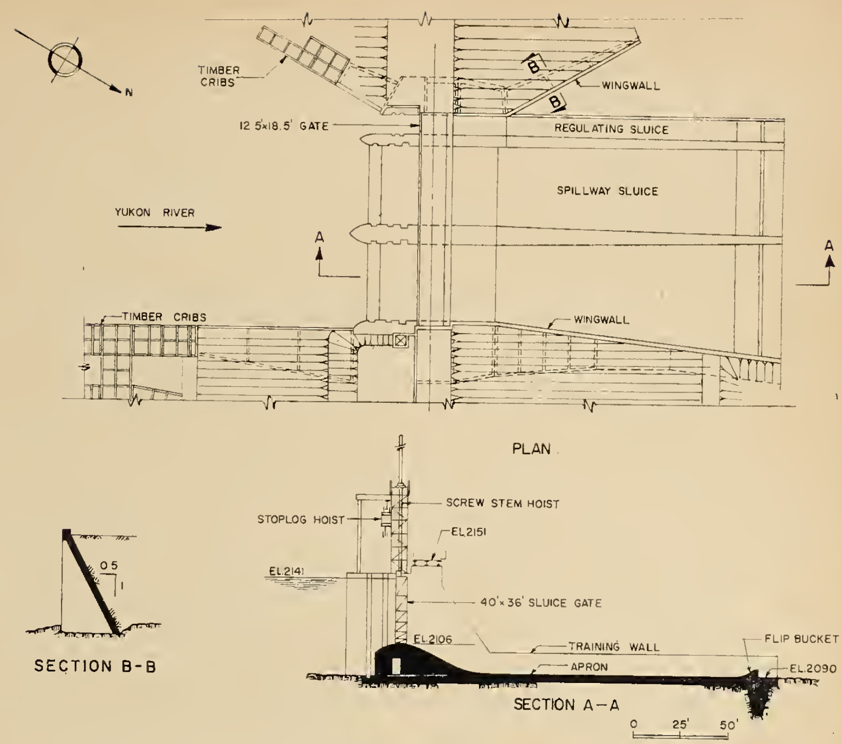


Fig. 2. Spillway Dam

On September 21st, 1958 the river flow at the power site was reduced from 14,500 c.f.s. to 6,200 c.f.s. by a fairly complete closure of the Lewes River dam. The first sluice at the spillway was unwatered on September 22nd without incident. The Lewes River dam was reopened on the same day, in order to lower the water level in Marsh Lake. The unwatering of the second sluice was carried out in late October, with the river flow temporarily reduced from 9,400 to 3,200 c.f.s., again by the closure of the Lewes River dam.

The third stage cofferdam for the fishway barrier dam was started in early August 1958, and completed in September. The river flow varied from 16,500 c.f.s. to about 15,000 c.f.s. while this cofferdam was being built. The contractor showed great ingenuity in launching timber cribs in 8 to 9 feet of water having velocities approaching 15 f.p.s. This cofferdam was removed in early October, and stage four cofferdam was started from the east bank, diverting the river between the completed transition wall and the west bank. The fourth stage cofferdam was removed in late April 1959, and the diversion channel was closed with a rockfill at the low river stage in May.

Spillway

The spillway, shown in Fig. 2, consists of two 40 ft. wide sluice openings and one 12 ft. 6 in. wide regulating sluice. The National Research Council tested a model of the spillway in 1957. The model study indicated the need of considerable downstream protection to avoid undermining the spillway structure and main dam transition wall. The concrete apron at the sluice exit was extended downstream some 130 ft. Flip buckets were provided at the end of the apron to throw the water clear of the structure, and hence avoid undermining. Training walls were required between the sluices to maintain the flow normal to the flip bucket when one sluice only was operating, and to permit unwatering of the apron for inspection and maintenance. A deep cutoff was provided under the flip bucket, as an added protection against the erosion which might occur at low flows, when the velocity is insufficient to throw the stream clear of the structure. The model also indicated the best operating procedure for the gates under various discharge conditions in order to minimize the erosion.

The transition walls between the spillway and earth fill structure are of counterfort construction with the slabs varying in thickness from 1 ft. 6 in. to 2 ft. 6 in.

The volcano which formed the river bed of the Rapids in geological times laid down successive layers of lava, varying from volcanic ash to dense basalt. A good deal of the lava was scoriaceous, that is, it was filled with air pockets up to ¼ in. diam. Laboratory tests proved that the voids were not interconnected and the rock was impervious. The rock loading was limited to 10 tons per sq. ft. in the design of the structures. The occasional strata were hard and appeared stable when first uncovered, but deteriorated to ash when exposed to air for some time. This was caused by hydration of the rock. The contractor experienced difficulty in clean-up prior to placing of concrete, when these strata were encountered.

Two sluice gates are provided, each 40 ft. wide by 36 ft. deep, and weighing some 80 tons. They are raised and lowered by electrically operated screw-stem hoists. The regulating gate 12 ft. 6 in. by 18 ft. 6 in. is cable-suspended and electrically operated. A 20 ton electrically operated cable hoist is mounted on a monorail upstream of the gates to raise and lower the steel stoplogs.

An access bridge across the spillway downstream of the gate structure was used for the gate erection. Heating elements were installed in the sills, guides and gates of the west sluice and the regulating sluice, to permit operation of these gates in winter.

Main Dam

The main dam is shown on Fig. 1, Section B-B. It is a conventional earth fill consisting of an impervious silt core, with a sand filter on the downstream of the core, and pervious gravel flanks. Riprap was applied to the top sections of the upstream flank and the lower section of the downstream flank, to afford protection from ice and wave action. The contractor used shovels and 12 cu. yd. trucks to handle the materials for this structure. The main dam was constructed in about five months in 1958.

The east bank of the river at the main dam consisted of bedrock, overlain with glacial till up to elevation 2120. The glacial till was covered to a depth of some 100 ft. with fine gravel and sand. The dam was tied into the east bank by means of steel sheet piling driven through the nearly completed core section into the glacial till contact at elevation 2120. The tie had to be effective against a head of 21 ft. of water. The sheet piling was carried into the bank some 25 ft. beyond the end of the impervious core, thus increasing the seepage path and insuring against any leaching of the impervious core at the contact with the sand of the east bank. This was more economical than a conventional blanketing operation.

A small spring developed about 400 ft. downstream from the dam centreline after the forebay was brought up to full supply level, but the water is clear, and no increase in flow has been noted.

Canal

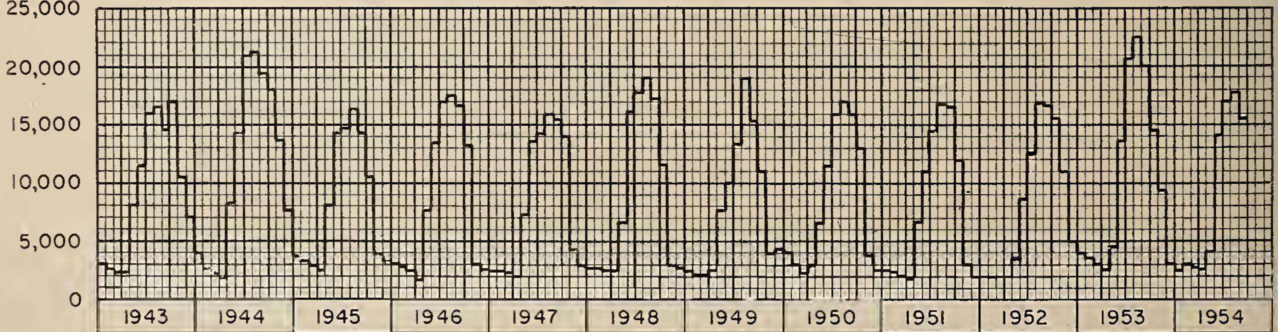
The canal layout is shown in Fig. 1. Its downstream end is founded mainly on pervious gravels, so that an impervious lining on the bottom was necessary. Laboratory tests of the local silts, made during the preliminary investigations, indicated their suitability for use in earthfill structures. The impervious layer of the canal blanket varied from a minimum thickness of 3 ft. to a maximum of 7 ft. 6 in., depending on the head. The gravels uncovered in the canal excavation were compacted "in situ", just prior to placing a 1 ft. thick layer of compacted sand. The impervious blanket was then placed to the designed depth, and covered with an inverted filter consisting of 1 ft. of compacted sand and 1 ft. of gravel. The blanket was carried across the canal and tied into the impervious core of the canal embankments. It was also tied into bedrock across the entrance to the canal proper, thus giving continuous protection from loss of water through the canal bottom.

A good deal of the local drainage from an area west of the canal percolates through the gravels on which the canal was built. The rock along the west bank of the river dips generally to the west. An overlay of fine sand over the bedrock adjacent to the slightly higher ground near the river resulted in a high water table at the downstream end of the canal. In 1957, a deep drain was cut from the river into this area, about 200 ft. upstream of the intake, and extended across the canal right-of-way. This lowered the water table some 6 ft. and permitted the contractor to excavate this area in the dry. The ditch was back-filled with oversize gravel from the aggregate screening operations. This drain functioned effectively throughout the winter of 1957-58. The only precaution taken before placing the canal blanket over the drain area was that 3 ft. of compacted sand was placed over the drainage ditch instead of the customary 1 ft. filter layer over the compacted gravel. A V-notch weir was installed at the outlet of this drain, and periodic flow measurements were made. This drain ran about 45 g.p.m. with little or no variation before and after the canal was filled with water.

Due to the gradient on the bottom of the canal (some 25 ft. in 2,000 ft.) special care had to be taken during the initial filling to prevent scouring of the canal blanket. Water was therefore pumped from the forebay (using a 10 in. diesel pump) into a stilling basin located at the head of the canal and constructed from a discarded section of the temporary fish ladder. From here 2,150 ft. of 1 ft. by 3 ft. wooden flume laid on an even gradient conveyed the water to the concrete intake slab, where it was discharged. As the water rose in the canal, the downstream end of the flume floated. The canal was filled in 5 ft. increments until the water level at the intake was raised 24 ft. to elevation 2129, about 1 ft. below the canal entrance. After each increment, readings were made on the drain discharge as described above and water levels were taken in the canal proper to check on possible water losses through the canal lining. This initial filling covered practically the entire bottom of the canal, thus protecting it from any frost penetration. It also gave a reasonable assurance that there were no major faults in the canal blanket.

It was not possible to raise the river to the level of the canal entrance

Fig. 3. Monthly Hydrograph of Yukon River at Whitehorse



until after the closure of the second sluice, in late October. The forebay level was raised to elevation 2134 early in November, and work was caried on in the sluiceway behind 46 ft. of steel stoplogs. The first unit was put into operation on November 15, with the forebay being maintained between elevations 2134 and 2135.

Intake

A three conduit intake was built in the initial stage, but head gates and trash racks were installed for conduits 1 and 2 only. The conduit for the future unit No. 3 was closed off by a bulkhead in the penstock. The hoist house is mounted on a slab supported on columns, high enough so that the headgates may be hoisted clear of the checks for inspection and maintenance. The head gates are operated electrically. Stoplog checks are provided upstream of the gate slots. The one set of steel stoplogs is handled by a manually operated monorail hoist. The same logs and hoist can also be used, if and when required, upstream of the regulating gate at the spillway.

The intake structure rests on undisturbed sand, covered by a layer of compacted gravel. The tie between the impervious layer in the canal blanket and the intake was effected with a special, ⅛ in. rubber sheet. The rubber sheet was placed on a compacted sand base and fastened to the intake base slab and to the base slabs of the two upstream retaining walls with bolted 3 in. angles. The sheet was extended upstream and embedded in the silt. At the intake entrance, a 6 in concrete wearing slab was placed directly on the compacted silt over the rubber sheet and the standard canal blanket was constructed immediately upstream.

Penstocks

All three penstocks, which are 12½ ft. diam., were installed. This will avoid the necessity of breaching the canal embankment when the third unit is added. The horizontal sections of the penstocks adjoining the intake and the powerhouse were embedded in concrete. The sloped sections were erected on a compacted sand base. The exterior surfaces of the penstocks, when not embedded in concrete were treated with a bitumastic coating. All penstocks were backfilled with gravel, after precautions were taken to avoid damaging the bitumastic coating. The penstocks were erected in the late summer of 1957, and two sliding joints were left in each penstock to allow for movements due to settlement. The sliding joints were welded in 1958, after the canal embankment was near completion. Settlement of

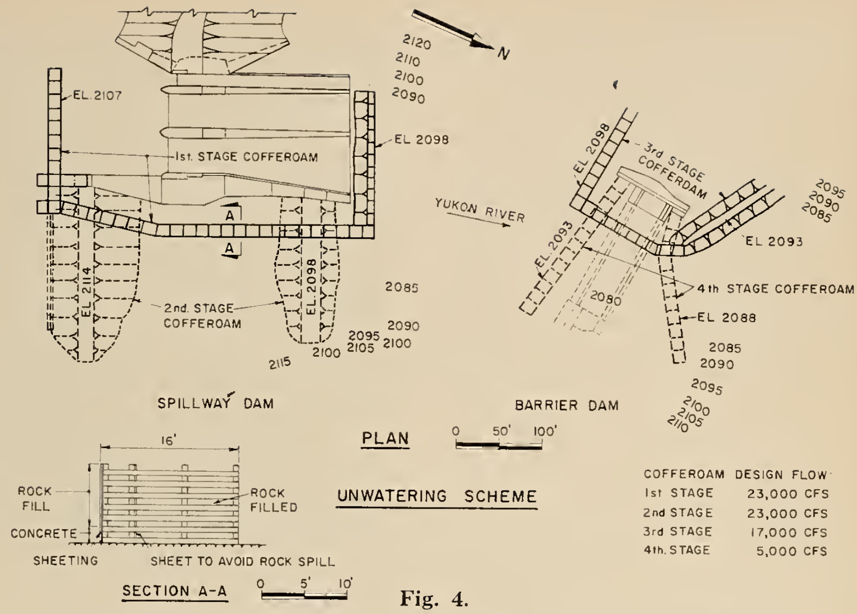


Fig. 4.

⅜ in. was observed at one joint only. Movement, if any, was longitudinal at the remaining joints.

No. 3 penstock will not be in actual use until the third unit is added. A timber bulkhead suitably backed with steel and designed for the full head on the plant was installed at the downstream end of the penstock. Two 2 in. pipes were put through the bulkhead and valved on the downstream side. The valves were left open, thus maintaining a small but continuous flow through this penstock. It is expected that this circulation will avoid major temperature fluctuations and prevent any significant icing in this penstock. The valves discharge some ten feet below the minimum tailwater level and are thus constantly submerged.

Powerhouse

The powerhouse excavation was completed for three units, but the substructure was built for the initial two units only. When starting the excavation, it was found that the bedrock was overlaid with a fine, saturated sand up to a maximum depth of 14 ft. The sand would not stand for any length of time, on a slope of less than 4:1, and it also went to a quicksand condition as soon as equipment worked on it. The excavation of this material was done by a 1½ cu. yd. dragline standing above, on the firm ground. A gravel dyke was carried around the perimeter of the excavation, directly behind the excavating equipment, thus trapping the sand before it could slough. Provisions were made to facilitate the unwatering of the excavation for the third unit at some future date, without interfering with the operation of the existing units.

The initial powerhouse structure contains two 7,500 hp. 300 r.p.m. Kaplan turbines which operate under a maximum gross head of 63 ft. Power is generated at 6900 v. by two 6700 kva., 300 r.p.m. generators. This voltage is stepped up to 34.5 kv. by two 5000/6667 kva. three-phase transformers for transmission to Whitehorse.

Some unusual difficulties were experienced with the governing of the turbines when they first started to take on load. Normally, load fluctuations on the Whitehorse system are small. However, during the commissioning of the plant the 3000 kva. electric boilers in the hospital were also being commissioned and, occasionally, the individual generating units had sudden load increases in excess of 1000 kw., or about 20% of their full load rating. When this occurred, governor action degenerated into violent hunting and, on occasion, the governors "locked out". On the other hand, performance during load rejection was satisfactory.

Mr. L. Avery was called to the site and during his investigation he noted that when load increases of over 1000 kw. occurred, the compensating dashpot on the governor was bypassed. This happened each time the opening movement of the big plunger of the dashpot was large enough to move the small plunger so near the end of its stroke as to uncover a slot on the opening end, and bypass the oil. The small plunger movement then ceased to have any compensating effect, and the unit began to hunt. Such bypassing of the dashpot is a desirable feature on sudden load-off, and a slot is provided for this purpose on the closing end of the small plunger. It was, however, the presence of the similar slot on the opening end of the small plunger, that was the cause of the trouble in this case. If the machine had formed part of the usual interconnected power system with abundant WR^2 stability, the trouble would not have arisen.

In order to prevent this hunting action, the pilot valve was centered with 5/16 in. blocks under the fly balls, instead of the ½ in. blocks usually used. This adjustment is such that, when the fly balls are forcibly collapsed against the spindle and the dashpot plunger held just clear of the bypass point, the distributing valve does not move beyond its centering point and, consequently, the gates do not open. At the same time the dashpot needle valve was set for maximum stability. Following these adjustments the performance of the governors was satisfactory. Loads of 2000 kw. were then "dumped" from one unit to the other without exceeding expected speed regulation. This was the maximum load available at the time for testing without using the town load.

On one occasion during the tests, with Mr. Avery present, the machine locked out. It was apparent to him that the lock-out was associated with hunting and low oil pressure. Evidently, under these conditions an accumulation of air collected behind the plunger of the automatic shut off valve causing the unscheduled closure. It was expected that with the elimination of the hunting this trouble would also disappear, but in order to make sure the drain line from the automatic shut off valve was modified to discharge directly into the oil sump above the oil level, where it would have free venting at all times.

Fish Facilities

At the start of the construction, in 1956, the decision as to the need for structures to facilitate the movement of anadromous fish was postponed. Meanwhile, the Department of Fisheries began an intensive investigation of the situation, and, as a result of their studies, it was decided in the spring of 1958 that a fishway should be provided. The Engineering Division, Pacific Area, Department of Fisheries then prepared a functional design which was incorporated into the project.

The fishway structures are shown in plan on Fig. 1. They are divided into two groups. One consists of a barrier dam to prevent the fish from reaching the confusing turbulence below the spillway flip bucket, and the ladder connecting the west end of the dam with the forebay. The other is a collection structure on the downstream wall of the powerhouse, and a transportation channel connecting this structure with the river below the barrier dam. The object of these structures is to return to the river those fish which swim up the tailrace.

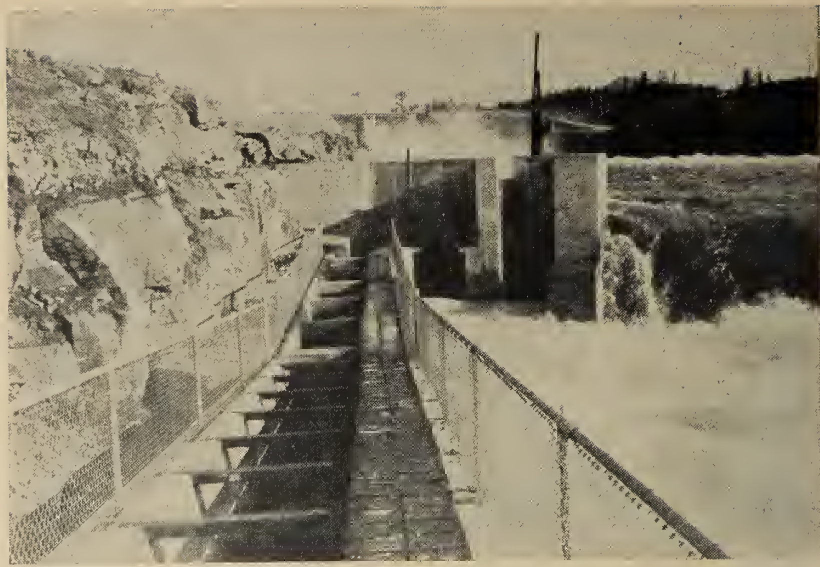


Fig. 5. Barrier Dam and downstream end of the Fish Ladder looking upstream.

Powerhouse Collection System and Transportation Channel

A collection chamber in the form of a timber flume with 3 submerged orifices was constructed on the downstream face of the powerhouse, above the draft tube openings. This chamber was connected to the transportation channel by means of a steel and timber aqueduct across the excavation for the future third unit. This will allow the fish facilities to operate without interruption, when the third unit is added. The transportation channel extends several hundred feet upstream to the head of the Rapids. Water at the higher elevation in the river flows down the transportation channel and passes into the tailrace via the submerged openings of the collection chamber. Fish entering the tailrace are attracted through these openings by the outflow, and ascend through the system back to the river to rejoin those that had proceeded directly upstream. The flow into the collection chamber is self-regulated by a system of slotted concrete baffles, which are adjusted to maintain the discharge and velocity within a specified operating range for all river stages between 10,000 and 25,000 c.f.s.

Barrier Dam

The barrier dam is located about 200 ft. upstream of the main rapids. A positive barrier was required, with a minimum surface drop of 8 ft., and a flow pattern of the overfall such that fish could not surmount it.

The structure was angled across the river in such a way that the fish would be led to the east bank, where the collection facilities for entrance to the ladder are located. Water is supplied to the collection system from the fish ladder, and an auxiliary supply of up to 600 c.f.s. is available, through a 6 ft. square slide gate in the east abutment of the barrier dam.

The west end of the barrier dam is a rock fill section constructed by end dumping. The final closure was made at low river stage, after closing the spillway gates for a few hours.

The design of the barrier dam and transportation channel was checked by a model study made prior to construction in the LaSalle Hydraulic Laboratory, Montreal.

Timber Fishladder

The fishladder, constructed of creosoted timber and reinforced concrete, approximately 1200 ft. long, and having a vertical rise of nearly 50 ft., allows the fish to swim from the collection facilities of the barrier dam to the forebay.

All of the fish facilities were placed in service on June 26th, 1959. During that year 1,054 Spring Salmon were counted going into the forebay.

Cost

The estimate for the power project was $7 million before construction was started, and the work was completed for $7.2 million. The fish facilities were estimated at just under $1 million and constructed for some $875,000.

Acknowledgements

The Whitehorse project was constructed for the Northern Canada Power Commission. The author acknowledges with thanks, the permission of Mr. E. W. Humphrys, General Manager of Northern Canada Power Commission, to present this paper and reproduce pictures taken during the progress of the work. He also wishes to express his appreciation to fellow members of the Montreal Engineering Company, who have assisted in the preparation of this paper. Special thanks are due Engineer R. N. Gordon of the Fisheries Department for data connected with the fishway facilities. EIC

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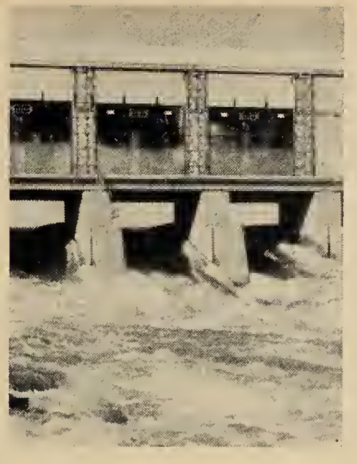


KELSEY GENERATING STATION DAM and DYKES

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

For the Kelsey Generating Station, the first hydro-electric development on the Nelson River, economic and schedule considerations dictated that a rock-fill dam be constructed on bedrock across the river and that dykes be constructed upon both unfrozen and permanently frozen foundations. For design of the 120 ft. high, 955 ft. long rock-fill sloping core dam, extensive laboratory testing was performed on the highly plastic core material. Construction delays and inclement weather conditions necessitated slight design modification, and it was also necessary to complete construction of the core within heated enclosures placed upon the dam. Dykes upon permanently frozen ground were constructed in winter, of sand brought to the site by rail. It is expected that the foundations will thaw gradually due to heat from the reservoir. Sand drains have been provided in the foundations to facilitate drainage and accelerate consolidation during thawing. Virtually no precedence was available and design had to be based qualitatively upon theoretical heat transfer and consolidation considerations. The latter involved testing, under carefully controlled conditions, samples of frozen and thawed foundation material. Sensitive temperature and settlement measurement devices have been installed in the foundations to check performance and design assumptions. These observations will serve to give warning of any impending troubles and will provide valuable information for the design of future water impounding structures on permanently frozen foundations. Considerable settlement is expected and periodical or continuing maintenance may be necessary on these dykes.

THE KELSEY Generating Station is a hydro-electric power development situated on the Nelson River, approximately 425 miles due north of Winnipeg, Manitoba. The station is owned by The Manitoba Hydro-Electric Board and was constructed for the purpose of supplying power for the mining and smelting operations of The International Nickel Company of Canada, Limited, some 60 miles distant at Thompson, Manitoba. The locations of the Kelsey development and Thompson are shown in Fig. 1. Construction began at Kelsey in June, 1957 and will be substantially completed during the summer of 1960. The initial installed capacity is 210,000 hp. The general arrangement of the development is shown in Fig. 2, and the pertinent statistics are given in Table I.

The Kelsey project involved the construction of a small rock-fill dam and a number of dykes which, because of the climatic and geological conditions at the site and the schedule requirements, gave rise to some geotechnical problems of unusual interest. The most significant factors were the low mean annual temperature, the short annual period of temperature favourable to earthwork construction, and the existence of appreciable but sporadic permafrost throughout the site. Construction of the main dam was governed by a reasonably tight diversion schedule and a short construction period; some difficulty was experienced in the use of a fairly plastic wet clay for core construction, and extreme difficulty was encountered with the very low temperatures existing during the later stages of its construction.

Two of the dykes, here referred to as sand dykes, had to be constructed in low swampy areas which were underlain by appreciable depths of permafrost. These were built directly upon the permafrost, an approach without any known precedent. Precautions were taken to ensure stability and the performance of these dykes will be watched with interest. For ease of access these dykes were constructed in winter; consequently they were built as homogenous sand fills rather than of rolled clay construction.

The remaining dykes were of more conventional types and presented no serious design or construction problems. They are here referred to as the clay dykes. Construction of one form or another was carried out during all seasons of the year.

Topography and Geology

The Kelsey site lies within the geological region known as the Canadian Shield,[1] which in Manitoba, as in most other parts, is a comparatively featureless region peneplained by erosion and several glaciations to its present surface of comparatively low relief. The bedrocks are of Precambrian age, and in the Manitoba area they are generally igneous or metamorphic types. During Pleistocene times this bedrock surface was eroded by the Laurentide ice sheet which covered most of Eastern Canada and gave to the area its comparatively thin cover of overburden consisting of glacial tills, glacial outwash deposits, and post-glacial lacustrine deposits. Since the relatively recent disappearance of the last glacier, the formation of a new surface drainage system has been progressing but, because of the flat topography and the nature of the overburden, this system is still highly disorganized and contains innumerable lakes, rivers, and swampy areas. The Nelson River threads its course for 375 miles from Lake Winnipeg to Hudson Bay and drops in elevation a total of 712 ft.

From the outlet of Lake Sipiwesk to the inlet of Split Lake, the Nelson River flows in an almost due north direction. The Kelsey power site is located four miles upstream from Split Lake at a point where the river turns through almost 90° and descends about 20 ft. through a narrow gorge, formerly known as Grand Rapid. Immediately below the rapid, the river turns through 180°, flows westerly about one mile, then continues its northerly flow into Split Lake. In following this course, the river has left a small rock-controlled peninsula separating the river at the two elevations. Above the falls, the normal summer river elevation was about 573 ft. and the deepest sounding was to elevation 530 ft.; the comparable figures below the falls are 553 ft. and 460 ft. Ground surface maximum elevation in the vicinit of the development is about 635 ft.

Rock outcrops are almost invariably confined to the shores of the river and the surrounding overburden is made up of varying thicknesses of glacially derived soils. The area is generally tree covered, with small to moderate sized growth and, as a result of the poor drainage, swampy areas and muskeg are common. Occasionally the latter are as great as 15 ft. in depth. Beneath the general cover of 1 to 3 ft. of organic topsoil, grey varved clays and silts occur which usually become less plastic and siltier with depth. In the top 6 ft. these are usually weathered to a brownish colour. These clays, which may exceed 25 ft. in thickness, were deposited in the post-glacial Lake Agassiz which formed behind the retreating ice sheet.[2] They are underlain by a glacially deposited ground moraine of sand, gravel, and granular till which varies in thickness from zero to more than 20 ft. The total thickness of overburden may vary from several feet to more than 50 ft., with the greater thicknesses occurring as infilling in depressions in the rock surface.

The country rock at the site is a medium to dark grey paragneiss which is thought to be a granitized sedimentary complex.[3] This has been

Fig. 1. Location of the development

intruded by acidic granite gneisses and by basic gabbro dykes and sills, the latter being in some cases of fairly massive proportions. The gabbros have been intruded by minor dykes of diabase and lamprophyre, whereas the gneisses contain a number of small pegmatite dykes. The major rock outcrops occur near the rapid and on the peninsula immediately north of the rapid. In the latter location the gabbroic rocks predominate.

The regional strike of the gneissic rocks is in the east-west direction, but at the Kelsey site there are some local deviations of a minor nature from this trend, probably associated with the basic intrusions. The principal jointing parallels the foliation, striking east-west and dipping to the south at 50° to 70°. Minor sets of jointing strike northwest-southeast and north-south and dip at very steep angles. Known structural weaknesses at the site are of a comparatively minor nature, the largest one being a small shear zone or fault in the riverbed at the rapid. Topographic evidence does, however, suggest that this may be associated with a larger fault parallel to it and in the river on the north side of the peninsula. Those shear zones found in the exploratory drilling are recemented, and it may be safely assumed that those faults which do exist in the region are inactive. Moreover, the Canadian Shield is considered to be among the world's most seismically stable areas,[4] and the probability of the Kelsey structures being subjected to earthquake loadings is extremely slight. The bedrock was found to be of a highly competent nature, capable of supporting all structures safely and of providing supplies of rockfill and concrete aggregate.

Permafrost

In the Kelsey area the mean annual temperature is 25° F and the mean January and July daily temperatures are respectively minus 15° F and plus 59° F.[5] The site experiences, on the average, only about 140 frost-free days each year.[6] The mean annual total precipitation is 16 in., about a third of which occurs as snow. Approximately a half of the total precipitation occurs during the months of June, July, and August.[5]

The Kelsey site is very near the southerly boundary of the permafrost region; that is, the region in which ground still remains frozen as a result of the last glaciation. Permafrost was encountered in some shape, manner, or form, during construction in approximately 70% of the entire area. Its occurrence was, however, found to be sporadic in both the

TABLE I

Statistical Data for Project

Reservoir:	
Drainage area at site	389,000 sq. miles
Reservoir area	200 sq. miles
Normal headpond elevation	605 ft.
Normal tailwater elevation	550–555 ft.
Flow:	
Recorded maximum flow	150,000 c.f.s.
Recorded minimum flow	23,500 c.f.s.
Average flow	72,000 c.f.s.
Sluiceway:	
Design discharge	250,000 c.f.s.
Gates	9-40 ft. x 43 ft.-6 in. fixed-roller crest type.
Powerhouse:	
Generating units	5-42,000 hp.
Initial installed capacity	210,000 hp.
Possible ultimate capacity	420,000 hp.
Dam:	
Length	955 ft.
Maximum height	120 ft.
Volume	288,300 cu. yd.
Clay Dykes:	
Total length	6,250 ft.
Maximum height	38 ft.
Volume	91,600 cu. yd.
Sand Dykes:	
Total length	3,900 ft.
Maximum height	20 ft.
Volume	97,500 cu. yd.

vertical and horizontal directions, and over only a small percentage of area was the soil found frozen completely down to the rock surface. In general, the zone of active frost was 2 ft. to 3 ft. thick in the swampy areas and where organic cover existed, and 5 ft. to 6 ft. on the more exposed higher ground. Beneath the active zone, the varved clay and sandy moraine were found frozen to depths as great as 35 ft. below ground surface and at some locations it was found within 25 ft. of the Nelson River. In some cases permafrost was found in the rock. Where permafrost was encountered in the clays, the frozen pore water occurred in several forms from evenly distributed minute ice crystals to lenses of clear ice as great as 7 in. thick. Ice lenses of such thickness were exceptional and were found mainly in the sluiceway area. The most common form consisted of thin threadlike ice stringers at the contacts between the light and dark layers of the varved clay. The temperatures in the permafrost were found to vary between 29.5° and 32° F.

Natural Construction Materials

At Kelsey the only two materials economically available in any quantity within the immediate area were the bedrock and the plastic varved clays. Suitable rockfill for the dam, dykes, cofferdams, roads and for concrete aggregate were obtained from the various excavations and the quarries shown in Fig. 2. As a well-graded glacial till material could not be found at or near the site, the varved clays had to be used for construction of the impervious zones in the dam and dykes and for sealing the cofferdams. While this clay is abundant at the site, its use was at times made difficult by the existence of permafrost, by its high natural moisture content, and by its relative thinness in some locations. Suitable sand and gravel deposits were not found at the site and both screened and unscreened sand for concrete aggregate and for dam and dyke construction had to be brought in to the site by rail.

Explorations

Preliminary site surveys were made by the Water Resources Branch of the Department of Mines and Natural Resources, Province of Manitoba, in the summer of 1955 and the winter of 1955-6. Hand auger holes were drilled in some locations to determine the nature and depth of the overburden. Preliminary field geological mapping was done in 1956 by The Canadian Nickel Company Limited, and a number of wash borings were made the same year by The Manitoba Hydro-Electric Board to determine overburden thicknesses. These were followed in late 1956 by photogeologic studies of the power site and the route of the railway line from Pit Siding to Grand Rapid. Additional explorations by diamond drilling and auger boring methods and more detailed geological mapping were begun in April, 1957, and were carried out intermittently until 1959 While most of the drilling was done by conventional exploratory methods, a departure from the normal was made in the investigation of the foundations for the sand dykes. Permafrost was known to exist at the locations of these two structures and it was considered necessary to obtain a reasonably complete picture of the foundation conditions. Continuous core from the frozen varved clay was obtained fairly successfully in the winter by the use of a double-tube, swivel-head core barrel with fuel oil as the drilling fluid.

Arrangement and Schedule of Development

The arrangement of the Kelsey development is shown in Fig. 2. The powerhouse is located to the west of the rapid on the north side of the peninsula. Water is supplied to the powerhouse through an intake channel which has been cut across the neck of the peninsula. The sluiceway is located in a cut made through another peninsula, that immediately southeast of the rapid. The river is blocked at the rapid by a rockfill dam. The dam extends from the sluiceway structure to the centre dyke which runs along the peninsula to high ground. Dyke No. 1 west extends from the west end of the powerhouse to high ground to the southwest. At the east end of the sluiceway, dyke No. 1 east provides a seal between the concrete bulkhead of the sluiceway and high ground in this area. South of the main structures two sand dykes, both founded on permafrost, one on each side of the reservoir, close low gaps around the reservoir. Several small freeboard dykes are located south of dyke No. 2 west on the west side of the reservoir.

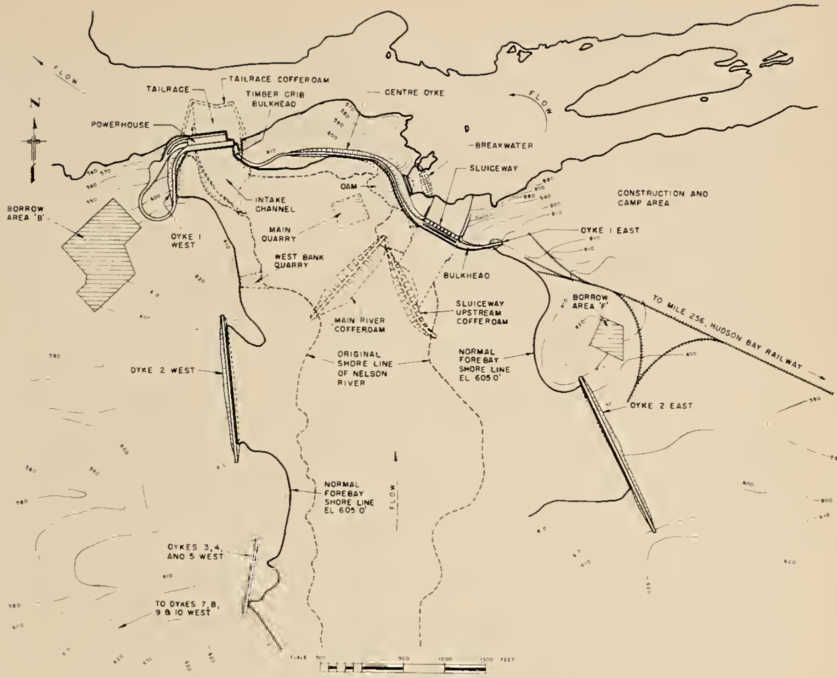


Fig. 2. General arrangement of the development

The operating level of the forebay will be elevation 605 ft., a level approximately 30 ft. above natural river level. This increase in water level plus the natural drop of approximately 20 ft. which existed at the rapid, provides an operating head of 50 to 55 ft. at the powerhouse. Under normal operation, the forebay level will be relatively constant; that is, it will fluctuate not more than 1 or 2 ft.

Access to the site is by a railway spur from the Hudson Bay Railway to the east or sluiceway side of the site. To obtain access to the west side of the river during construction, a temporary precast post-tensioned concrete bridge was erected to span the river immediately downstream from the main dam location.[7]

The construction schedule required that the sluiceway cut be excavated during the summer, fall, and winter of 1957, that the sluiceway structure be constructed during the year 1958, and that the Nelson River be diverted through the sluiceway during the low flow period in early spring 1959. Diversion of the river was accomplished by building a cofferdam across the river just west of the sluiceway intake at the location shown in Fig. 2. Construction of the rockfill dam was begun immediately after diversion and was completed by the end of 1959. The two longest clay dykes (the centre dyke and dyke No. 1 west) were constructed during the summer of 1959; the sand dykes during the winters of 1957-1958 and 1958-1959. Scheduling of powerhouse construction was relatively independent of that of other structures, except for dyke No. 1 west which abuts it.

The unwatering and diversion sequence involved the construction and removal or partial removal of some large cofferdams. A rockfill clay-sealed cofferdam was constructed immediately upstream from the sluiceway intake. This permitted excavation of the cut and construction of the sluiceway structure to be done in the dry. After completion of this work, this cofferdam was removed to the sluiceway cut invert level. The main river cofferdam, similar in construction to the sluiceway cofferdam, was then advanced north-eastward a total of 1300 ft. across the river to divert the entire flow through the sluiceway. The potentially difficult closure of this cofferdam was achieved with comparative ease, as the river flow at the time of closure was down to 45,000 c.f.s. from a flow of 80,000 c.f.s., which was the maximum likely to occur at this time of year. This cofferdam served as the upstream cofferdam for the construction of the dam and also for completion of excavation of the powerhouse intake cut. The downstream cofferdam for the dam consisted of the first stage of the dam rockfill, sealed on its downstream side by clay. The cofferdam for unwatering the powerhouse and tailrace was a rockfilled timber crib with steel pile sheeting.

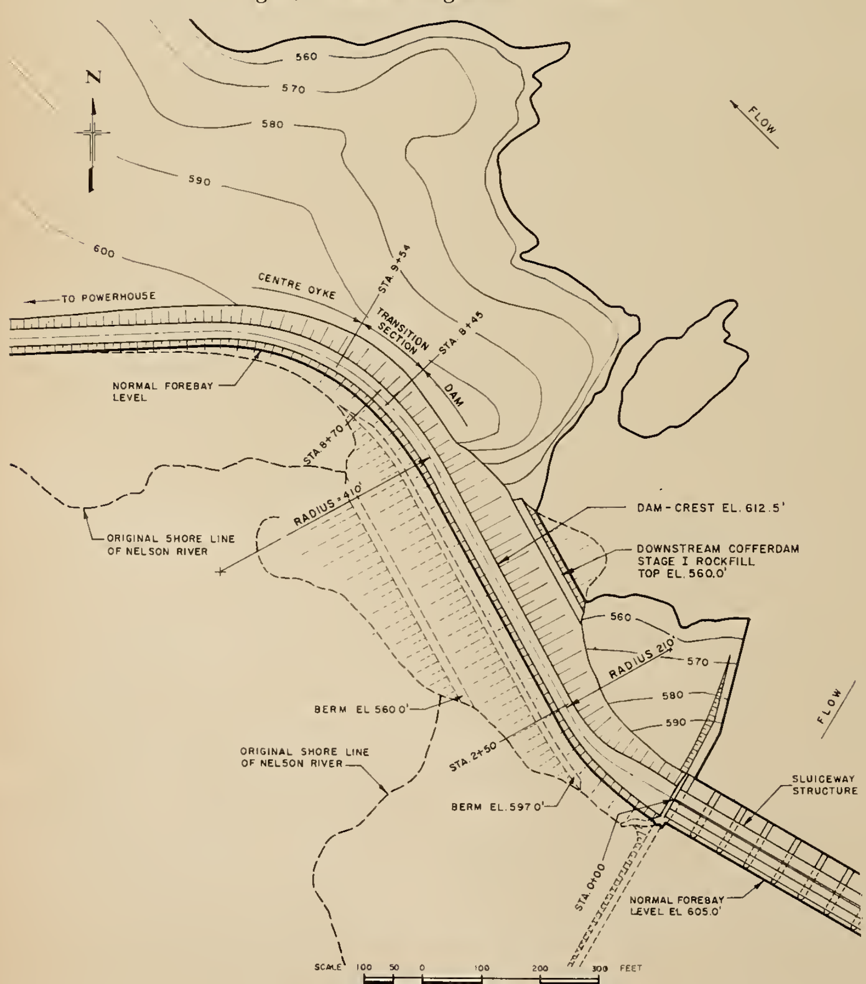
Dam Design

Arrangement and Type:

The approximate locations of the major structures were determined by the general arrangement of the project which required that the Nelson River be blocked by a dam about 120 ft. high at, or very near, the rapid. The exact location and the orientation of this structure were determined in such a way that the volume of materials required would be as small as possible and that the permanent access provisions would be both satisfactory and consistent with the greatest overall economy. These considerations resulted in the dam being located so that, together with the sluiceway to which it abuts on the south bank, and the centre dyke which it joins on the north bank, it describes a long reverse curve with the main portion of the dam occupying a straight section, about 480 ft. long, in the centre. The general arrangement of the dam is shown in Fig. 3.

The dam is of the rockfill type with an upstream impervious sloping core. It has a crest length of 955 ft., a maximum height of 120 ft., and contains 288,300 cu. yd. of material. Sound rock existed at the surface or at a very shallow depth throughout the actual damsite, and foundation conditions were suitable for the construction of several types of concrete or rockfill dams. Consideration was given to a concrete gravity structure, but in view of the availability of good quality rockfill from either structural excavations or from quarries, a rockfill dam proved to be appreciably more economical and was consequently adopted.

Fig. 3. General arrangement of the dam



The sloping core design was chosen in preference to one with a vertical or near-vertical core, chiefly because of the greater flexibility in construction scheduling that is achieved with it. The downstream cofferdam is an integral part of the dam and was designed to be constructed as stage one of the main rockfill placing operation. The remainder of the main rockfill was designed to be placed in one high lift at a rapid rate in order to permit the construction of transition zones, impervious core, and supporting zone to proceed independently. Where a short construction season and uncertain weather conditions are encountered, this flexibility in scheduling the material placing is advantageous. A typical cross section of the dam is shown in Fig. 4.

Dam Materials: Rock for both stages of the main rockfill and for the supporting zone was permitted by the specifications to vary in size from rock dust, which together with rock smaller than 4 in., unsound rock, and soil, was not allowed to constitute more than 15% of any load, to a maximum size which was to be determined only by the capacity of the loading and hauling equipment. These specifications were rigidly enforced for the main rockfill, but for the supporting zone these were relaxed somewhat to allow the use of finer rock which was produced in the sluiceway excavation.

The impervious core is protected by three transition zones on the downstream side and two on the upstream side. The material for zones A and D was a natural sand, and those for zones B, C, and E, were produced by crushing and screening rock at the site, and were broadly specified as follows:

Zone B — 1½ in. to ¼ in.
Zone C — 7 in. to 3 in.
Zone E — 7 in. to 1½ in.

The gradation ranges of the impervious core material and the transition materials actually used are shown in Fig. 5.

Borrow pit explorations indicated that the varved clay deposits con-

TABLE II

Ranges of Properties of Borrow Pit Materials

	Brown Plastic Clay	*Grey Silty Clay*
	%	%
Clay content	55—80	30—45
Liquid limit	45—65	30—40
Natural water content	26—32	23—25
Approximate optimum water content*	25	15

*As determined by the Standard Proctor Compaction test.

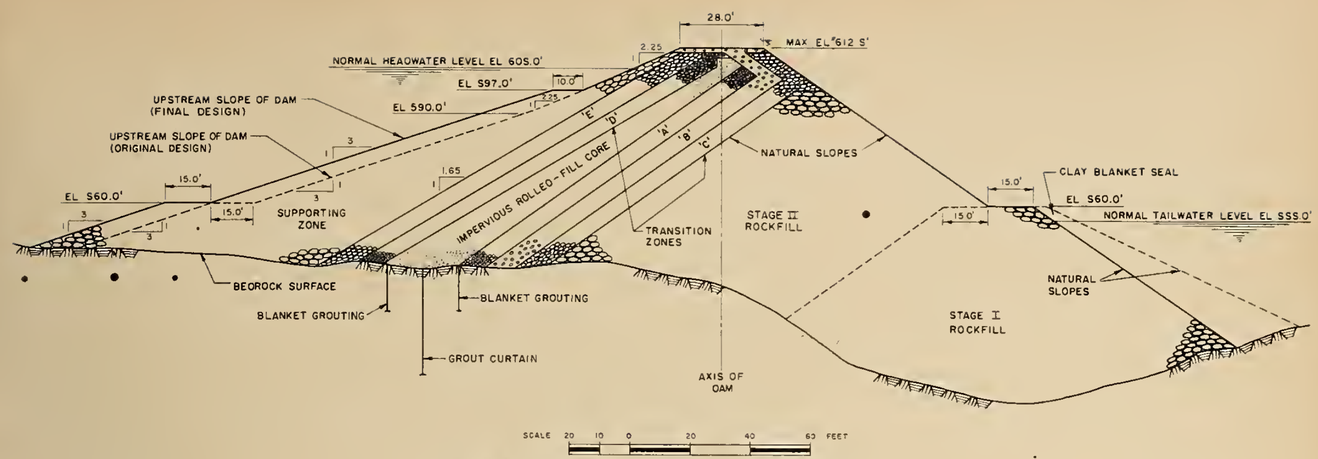


Fig. 4. Typical Section through the dam

tained soil of varying properties. The upper 4 ft. to 8 ft. consisted of a brown plastic clay. Beneath this upper layer, the clay became less plastic with depth and more greyish in colour. Underneath this grey silty clay, and just above the rock surface, there was a layer of almost pure silt which was not used in the dam or dyke construction. The comparative properties of the brown plastic clay and the grey silty clay shown in Table II were determined during borrow pit investigations prior to construction.

Early considerations suggested that the brown plastic clay would, because of the greater plasticity and smaller disparity between the natural and optimum water contents, be more easily handled and placed by the construction equipment. The design of the upstream slope of the dam was, therefore, based upon the assumption that this brown plastic clay would be used. Accordingly, a complete set of triaxial compression tests including consolidated undrained, unconsolidated undrained, drained, controlled stress ratio, and pore pressure dissipation tests, was performed on a sample of this clay with the properties shown in Table III.

Stability, Settlement, and Seepage: Stability calculations were made by the slices method[8] for varying geometrical shapes of the upstream slope. These analyses were made in terms of effective stresses and were two-dimensional in scope.

TABLE III

Properties of Brown Plastic Clay

Specific gravity	2.70
Clay content	58.0%
Liquid limit	62.3%
Plastic limit	28.1%
Plasticity index	34.2%
Activity	0.59
*Optimum water content	24.7%
*Maximum dry density (pcf)	96.8
Coefficient of permeability (f.p.m.)	3×10^{-8}
Shear strength parameters—see following discussion.	

*As determined by the Standard Proctor Compaction test.

Three conditions of loading were considered, the construction case, the steady seepage case, and the drawdown case. The placement water content was assumed to be 31% and from the triaxial tests the effective shear strength parameters for the construction case, c' and $\varnothing'$, were determined to be 150 p.s.f. and 24° respectively. The pore pressure parameter $\bar{B}$[9] was estimated from the triaxial tests to be 0.55. Using these values, the minimum overall safety factor for a slope of 2.25 to 1 above elevation 590 ft., and 3.0 to 1 below elevation 590 ft. with a 15-ft. berm at elevation 560 ft., was calculated to be 1.52 for the case where the dam was completed to full height and the rising reservoir had reached elevation 565 ft.

For the steady seepage case, it was assumed that the core was completely saturated and that the steady seepage flow net for a reservoir elevation of 605 ft. had been established. The pore pressures were determined from this flow net and c' and $\varnothing'$ were determined from the triaxial tests to be 70 p.s.f. and 23° respectively. The minimum safety factor for the same upstream slope for this condition was determined to be 1.90.

For the drawdown case, it was assumed that steady seepage conditions had been established and that drawdown took place instantaneously $\bar{B}$ was therefore assumed to be 1.0 and the minimum safety factor was found to be 1.45 for the maximum possible drawdown to elevation 570 ft.

The material actually used for core construction consisted largely of the grey silty clay with the properties shown in Table V. Laboratory tests had shown that the effective strength parameters of this material differed only slightly from those determined for the brown plastic clay, c' and $\bar{B}$ being slightly higher and $\varnothing'$ remaining essentially the same. However, the very wet state of the material which resulted from the borrow pit conditions and the necessity to complete the dam in 1959, led to the conclusion that pore pressures higher than those assumed would occur. In order to maintain the same minimum overall safety factor of about 1.5, the upstream slope was modified to that shown in Fig. 4 by the continuation of the 3.0 to 1 slope up to elevation 597 ft., and the addition of a 10-ft. berm at that level. The dam was constructed to this section.

The rockfill and the transition materials were assumed to have the properties shown in Table IV.

TABLE IV

Properties of Rockfill and Transition Materials

	Rockfill	*Transition Materials*
Porosity	29%	26%
Moist density (pcf)	120	125
Submerged density (pcf)	76	75
Angle of shearing resistance ($\varnothing$ in degrees)	45	40

In a sloping core rockfill dam of the Kelsey type, settlement of the crest can be expected to occur as a result of the adjustment of the rockfill to the increasing load. The magnitude of this settlement is impossible to calculate rationally but, on the basis of past experience, it is expected to be very small and to take place largely during construction. An allowance of 18 in. was made by superelevation of the crest; that is, 1.25% of the height of dam. Monuments were established along the crest to determine the movements of the dam.

Seepage from the reservoir through the impervious core will be negligible in view of the extremely low permeability of the clay. The downstream transition zones A, B, and C, have, however, been designed in accordance with accepted practice and, where applicable, established filter criteria[10] to prevent migration of particles from one to the next.

To control seepage through the rock beneath the dam, blanket and curtain grouting was performed, and consisted of three rows of holes beneath the core and extending from Station 0+00 to Station 8+70. The outer two rows consisted of 15 ft. deep holes at 20 ft. spacings, whereas the centre row consisted of holes varying in depth from 15 ft. on the abutments to 50 ft. at the deepest part of the dam foundation. These holes were also spaced at 20 ft. centres. Additional grouting to treat zones of fractured rock was specified as required.

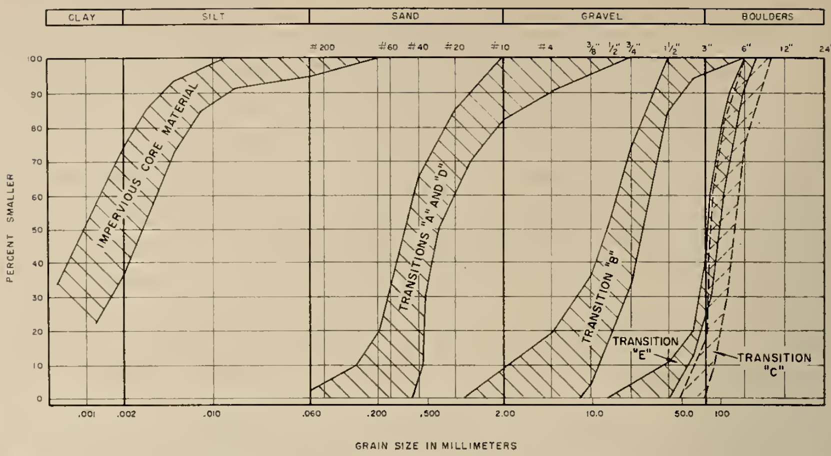


Fig. 5. Particle size distribution of impervious core and transition materials in the main dam

Dam Construction

Unwatering: The upstream cofferdam across the Nelson River was constructed as described previously. It was closed in February, 1959 and effectively sealed in June, 1959. A small secondary upstream cofferdam was built just upstream from the riverbed quarry to facilitate unwatering of the immediate area of the dam. The downstream cofferdam across the river was, for reasons of economy and because of space restrictions, incorporated as stage one into the construction of the rockfill. This rockfill was completed in April, 1959 and was effectively sealed in July, 1959. The design of the downstream cofferdam was similar to the one upstream in the main river, and consisted only of a layer of clay deposited in water on the face of the rockfill. Considerable difficulty was encountered in producing an effective blanket seal, and this was attributed to the erosive action of the flow through the sluiceway as it emerged in close proximity to the toe of the cofferdam. This difficulty was eventually overcome by the construction of a rockfill breakwater immediately downstream from the cofferdam.

Seepage into the immediate area of the dam was collected in two natural sumps, one on each side of the impervious core. The larger amount of seepage was collected in the downstream sump and this was removed by a submersible pump installed at the bottom of a 30 in. diam. corrugated steel pipe, laid between the main rockfill and transition zone C and running up to about elevation 595 ft., to discharge outside the downstream cofferdam. Pumping on the downstream side of the core was continued until construction was sufficiently advanced to allow the water pressures on both sides of the core to be equalized. Pumping was then discontinued and the 30 in. pipe was filled with concrete.

Foundation Treatment: The abutments of the dam above water level were generally covered with clay varying in depth from 3 ft. to 15 ft., whereas beneath the river level the rock surface was relatively clean and smooth, although highly irregular. As much as 15 ft. of sand, gravel, and boulders, were found in the deepest part of the riverbed, and boulders up to 6 ft. diam. were found on the south bank. The rock was mainly a hornblende-biotite gneiss which was cut by numerous vertically dipping pegmatite and gabbro dykes. Surface weathering of the rock was of very limited depth, but weathering along joints particularly near the former water line, extended to depths as great as 8 ft. The rock surface beneath the river contained many shallow potholes and a number of larger ones ranging up to 10 ft. diam. and 10 ft. deep. Steep rock faces had been formed along both sides of the river in its deepest part because of the nearly vertical dip of the foliation joints, and along the south bank this face was overhanging. Near the foot of this south wall, a steeply dipping 9 ft. wide shear zone was found striking in an east-west direction. Several other minor shear zones were found, but all such structural weaknesses were tight.

The specifications required that the area beneath the impervious core and transition zones A, B, and D, be excavated to sound rock. The initial stripping was done with a bulldozer and a dragline and the final cleaning was done by sluicing and hand labour. About 3600 cu. yd. of loose and overhanging rock were removed by trimming back the walls to slopes of 1 horizontal on 2 vertical. The previously mentioned shear zone, the potholes, and the badly weathered joints, were dug out to depths which reached a maximum of 8 ft. in the shear zone, and were subsequently filled with concrete to provide a conveniently smooth area upon which to place the clay core material. Approximately 900 cu. yd. of concrete were thus placed. The minimum rock elevation reached was 492 ft.

Beneath the main rockfill, the supporting zone, and transition zones C and E, pockets of gravel and boulders were allowed to remain in place, and cleaning of the rock was confined to the removal of clay and sand and the cleaning of the larger potholes which were subsequently refilled with graded rock.

After the cleaning and surface concreting had been completed in the core area, the grouting of the rock was begun. The two outer rows of blanket holes and the shallower holes in the centre row were drilled with jackhammers, whereas the deeper curtain holes were diamond drilled with AX size bits. One hundred and forty-nine holes with a total length of 2816 ft. were drilled, pressure washed and pressure tested prior to grouting. Cement grout was used throughout and was injected into the holes in stages from the bottom of the hole up, using a single expander. Grouting pressures were limited to 20 p.s.i.g. at the surface and increased by 1.5 p.s.i.g. for each foot depth of rock and concrete. Of the 149 holes drilled, 80 accepted no grout and the remaining 69 accepted a total of only 123 bags of cement. Most of this grout penetrated the jointing in the upper 3 ft. of rock, and virtually no grout was consumed at the lower elevations in the curtain holes. In view of this experience in the first few 50 ft. long holes, the length of the remaining holes was reduced to 30 ft.

Rockfill: The rockfill placing was divided into three parts: stage one, which constituted the downstream cofferdam, stage two or the main rockfill, and the upstream supporting zone. The rockfill was obtained from the excavations of the sluiceway channel, the intake channel, and the powerhouse, and from two quarries, one on the west bank about 1800 ft. southwest of the dam, and the other in the riverbed immediately upstream from the dam. In the riverbed quarrying operation, a 20 ft. to 35 ft. face was worked, and drilling of 2.5 in. diam. holes on a 7 ft. by 7 ft. spacing was done with wagon and track-mounted percussion drills. The loading of rock was done with 2½ and 1½ yd. shovels. Hauling was done by 15 ton and 18 ton trucks and 34 ton PR20 and PR21 rock wagons. The greatest number of hauling units working at any one time was eight trucks and six rock wagons.

The stage one rockfill was obtained directly from the powerhouse excavation and from stockpiles of rock from the sluiceway channel. It was end-dumped into the river from a 35 ft. to 40 ft. wide crest at an elevation of 560 ft. The maximum height of this fill is about 65 ft. and, although it could not be sluiced during placing, it is considered that adequate compaction was achieved by virtue of the water flowing through the fill at the time of placement.

The stage two rockfill was obtained from stockpiles of rock excavated from the sluiceway channel, the powerhouse, and both quarries. It was deposited in three lifts, the first of which progressed outwards from the north abutment at a crest elevation of 586 to 590 ft. The maximum height of this lift was, therefore, about 90 ft. The lift was sluiced during placing with a water jet directed from a manually controlled monitor mounted at the end of a 50 ft. long cable-controlled boom attached to a D-6 bulldozer. The nozzle pressure was 125 p.s.i.g., and the volume of sluicing water was four times the volume of dumped rock.

Following the completion of the first lift, a layer of up to 3 ft. of fines was removed from the crest by backhoe and sluicing. A second lift of about 10 ft. in height was placed using selected rock with no sluicing. The final lift of about 3 ft. was placed at the same time as the upper portion of the impervious core to bring the main rockfill up the finished elevation of 596-598 ft.

The supporting zone rockfill was obtained from the stockpiled sluiceway channel rock and from the riverbed quarry. For reasons of stability, its top elevation during construction was maintained very nearly equal to that of the impervious core. This was done by placing a zone of small rock adjacent to transition zone E in 2 ft. to 3 ft. lifts and by end-dumping large rock on the upstream face of this zone. The upstream face of the dam was trimmed to its final lines and grades with a bulldozer and a backhoe. No sluicing was done on the supporting zones.

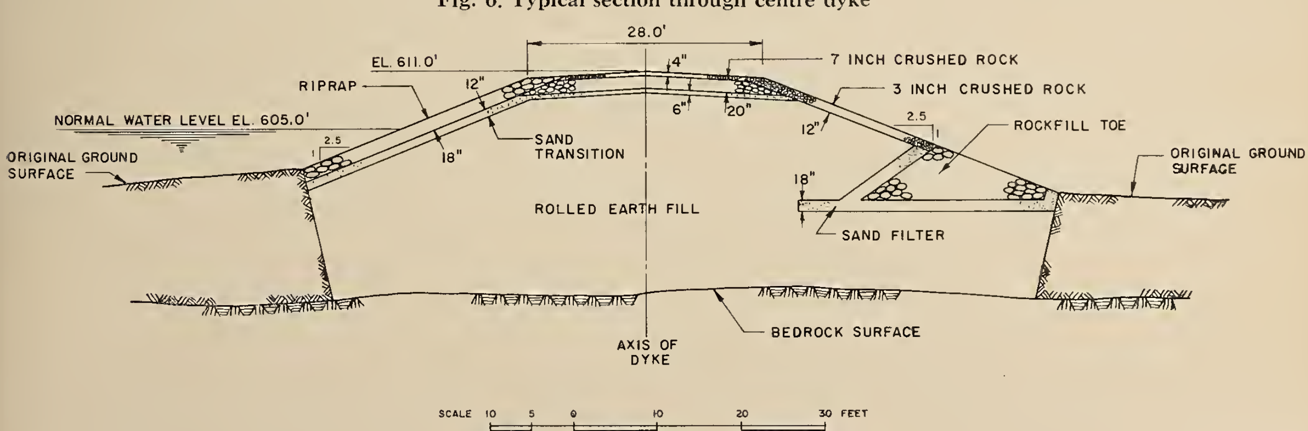
Transition Zones: The material for transition zones C and E was produced at the site by crushing and screening rock from the various excavations and the two quarries. Some of this was stockpiled and used later, while some was taken directly from the crusher to the dam. The transition C material which had a 7-in. to 3-in. grading was, for reasons of access, placed by dumping from the top of the rockfill. Despite the heights of dumping, which exceeded 70 ft., segregation of the material was not appreciable. The transition E material had a 7 in. to 1½ in. grading, although above elevation 590 ft., some 3 in. to ¼ in. was substituted. Transition E was placed in 1 ft. thick lifts which were never more than about 2 ft. below the adjacent transition D level.

Transition B material was produced by crushing and screening excavated and quarried rock at the site. A temporary shortage of this material developed during August and September of 1959, and approximately 8,000 cu. yd. of crushed and screened gravel were brought in by rail from Thompson. The transition B material was deposited in the deep channel section from the south wall by a chute, then spread by bulldozer. Above elevation 550 ft. it was dumped at various points from the top of the rockfill and spread and compacted by bulldozer. Placing of this zone was allowed, for convenience in construction, to reach a level as much as 15 ft. in advance of transition A.

The sand for transitions A and D was a selected pit-run material obtained from a large excavation previously established at pit siding. It was excavated in the pit by a dragline and hauled in rock wagons and trucks to the rail spur where it was stockpiled. It was then loaded into gondola railway cars with a dragline and hauled the 13 miles to the site where it was unloaded with a clam bucket and taken to the dam in trucks. At the lower elevations the sand was placed through a 24 in. diam. pipe located on the south bank, while above elevation 540 ft., the pipe was located on the main rockfill. The material was spread and compacted with D-6 and D-4 bulldozers. To achieve the specified 75% of relative density, material was placed in layers less than 6 in. thickness. Difficulty was experienced in late 1959 with freezing of the sand, and calcium chloride was added in amounts up to 10 lb. per cu. yd. of sand to allow placing at temperatures down to 0° F. Transitions A and D were both maintained at all times within a few feet of the elevation of the impervious core.

Impervious Core: The clay material for impervious core construction was present in almost unlimited quantities near the site and a number of potential borrow pits were demarcated. It proved necessary, however, to use only two of these, borrow areas B and F. Most of the material for the dam came from area B, with area F being used near the end of construction when continued

Fig. 6. Typical section through centre dyke



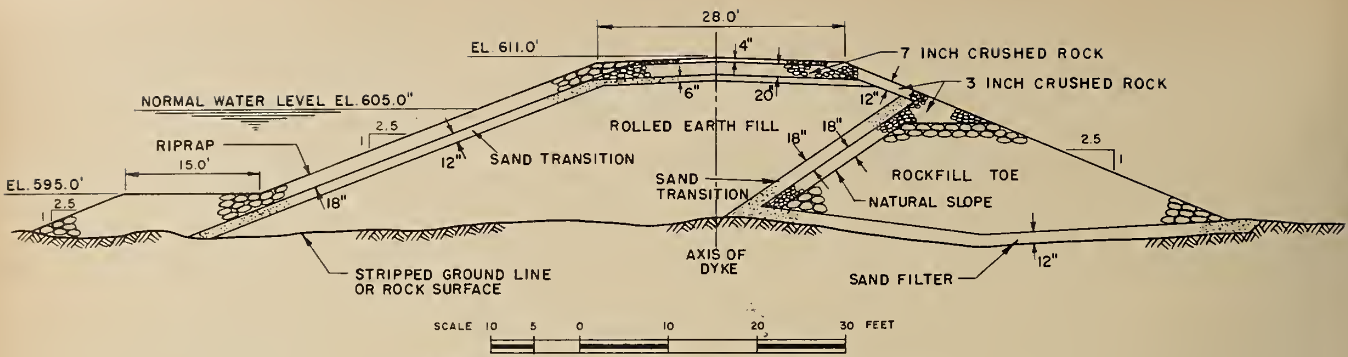


Fig. 7. Typical section through Dyke No. 1 West

operation in area B became difficult.

Stripping of the borrow areas was done as much as possible in the early spring months before the ground and organic cover thawed. Access into the pit was made difficult by the highly plastic nature of the clay, by its high natural water content, and by the occurrence of frequent rain. Consequently it was necessary to build good rockfill roads into the pit. The material was excavated with a 1½ yd. dragline and hauled to the dam in 10 ton tandem dump trucks. The maximum length of haul was almost one mile.

The clay was spread along the core with D-6 and HD-21 bulldozers and compacted in 6 in. layers with a four-wheel pneumatic-tired roller, ballasted only to a total weight of 13 tons. Above elevation 590 ft. the lifts were made thinner and compacted only with bulldozers. Pneumatic hand compactors were used in locations near rock surfaces and structures which were inaccessible to the roller. It was hoped that it would be possible to use only clay with a water content less than 120% of the standard Proctor optimum value and to obtain densities in excess of 95% of the standard Proctor maximum. However, in spite of attempts to drain the borrow pit and promote rapid drying of the material, it proved impossible to meet these requirements. Clay with a water content up to 130% of Proctor optimum was allowed to be used and densities as low as 90% of Proctor maximum were accepted. The average values were respectively 123% and 92%. To compensate for these lower densities, the upstream slope was further flattened and another berm was added at elevation 597 ft. as mentioned previously under "Design".

In late September, when the fill had reached elevation 588 ft., difficulty was experienced with freezing of the clay and, to overcome this, 78% fused-flake calcium chloride was added to the fill as it was loaded into the trucks at the pit in amounts of 5 lb. per cu. yd. of clay. Placing at any time was restricted to small areas of the core but freezing of the fill continued and frequent delays resulted from the need to stop placing and scrape off as much as 6 in. of frozen clay from the surface. In this manner the elevation of the fill was brought up to 591 ft. by October 7, at which time the daily range of temperatures was approximately 22° to 35° F.

The temperatures continued to drop, but the need to complete the dam and dykes before March 1960 led to the decision to finish the core placing under a heated enclosure. A timber framework, 19 ft. wide by 96 ft. long, was built and covered with polyethylene tarpaulins. Heat was supplied within this cover, and placing of fill beneath it was begun on November 6, at which time the daily range of temperatures was approximately 0° to 15° F. Placing within this enclosure continued as it was moved along the dam, and the fill was completed on November 22. Clay was not placed when the outside temperature fell below 0°, and the temperatures within the enclosure were maintained between 25° and 35° F. during this period. The calcium chloride content was increased to 10-15 lb. per cu. yd. and the trucks were covered with tarpaulins during transit. At the same time, it became necessary to remove the frozen surface material in the borrow pit by drilling and blasting.

Construction Statistics: The necessity to provide access at the north end of the sluiceway deck prior to the diversion through the sluiceway required the construction of a portion of the main dam between Stations 0+00 and 2+50 in the autumn of 1958. This was accomplished in August, September, and October, of that year. The stage one rockfill was completed in April, 1959, and stage two was completed near the end of August. Considerable difficulty was experienced in gaining access to the river channel after unwatering and it was not until August 13 that a road was cut through the steep rock bank to the riverbed. Foundation treatment and grouting proceeded throughout July, August, and the first half of September, and it was not until August 30 that the first clay was placed in the core. Between that date and November 22 the core, transition zones, and supporting zone were raised from about elevation 500 ft. to the finished elevation of 612.5 ft. A summary of the quantities of materials placed appears in Table VI.

Clay Dykes

Centre Dyke: Early explorations in the centre dyke area showed that the overburden consisted of a varved clay underlain by a thin layer of sand and gravel. Bedrock, which was mainly granite gneiss with numerous gabbro dykes, lay beneath the sand and gravel. Extensive zones of permafrost were found in the overburden. Subsequent excavation confirmed the widespread existence of permafrost with ice lenses up to ½ in. in thickness in the varved clay. It was concluded that the filling of the reservoir would change the existing thermal regime sufficiently to produce extensive thawing of the permafrost and that this would probably result in critical stability conditions in the dyke foundation. It was, therefore, decided to remove the overburden down to bedrock from beneath the dyke and to replace it with compacted unfrozen clay. This was done for a distance of approximately 850 ft. beyond the end of the dam, to the point where the natural ground surface reached elevation 605 ft. At this point, the height of the dyke is approximately 5 ft. and it was placed directly upon the stripped overburden. For this dyke, a homogeneous rolled earth-fill section was chosen because abundant impervious clay was available and no problem in connection with access for construction equipment was anticipated. A typical section of this centre dyke is shown in Fig. 6.

The clay fill was obtained from the upper layers of borrow area B. The properties of this clay are shown in Table V. It was placed several per cent wet of optimum and the resulting densities were somewhat lower than the maximum values. However, these variations from optimum placing conditions were insufficient to require any modifications in the comparatively flat slopes of the original design. Settlement within the dyke is expected to be small because of the low height, and virtually no seepage will occur through it because of the low permeability of the clay. A rockfill toe draining into the rockfill of the dam was incorporated to take care of surface runoff.

Sand for the transition layer and the toe filter was obtained from pit siding while the crushed rock for road dressing and downstream slope protection was obtained from the same sources as the comparably sized dam transitions. The riprap and the rockfill toe material were obtained from excavations and the quarries.

The overburden was stripped with a dragline after attempts to remove it with bulldozers proved unsuccessful, and the frozen material was disposed of close by, on the upstream side of the dyke. The bedrock was found to be sound and the joints tight. The surface was sluiced clean and the potholes were thoroughly cleaned, but no excavation of rock and no contact grouting were considered necessary. The excavation for the dike was made in the summer of 1958 and the side slopes were cut to, and left at a very steep angle until the placing of fill began in the early summer of 1959. Some difficulty was encountered with the thawing and sloughing of these slopes during placing operations. This was overcome by packing clay fill against them temporarily and subsequently removing this just prior to the placing of the permanent fill. The clay was hauled in 10 ton and 15 ton trucks, spread by bulldozers, and compacted in 6 inch lifts with loaded 10 ton and 15 ton rubber-tired trucks.

The junctions between the sloping core and the transitions of the dam and the corresponding zones of the homogeneous section of the centre dyke were unavoidably complex. The transition between the two types of section was accomplished over a length of about 90 ft. The visualization of the transition was facilitated, both in the design office and at the site, by the use of a block model.

Overburden excavation and foundation preparation were done mainly in August and September, 1958, and were finally completed in July, 1959. Fill placing began in May, 1959, and was completed in mid-November of that year under very severe conditions of freezing weather. Construction on this dyke was suspended during the period of intensive work on the dam when all available equipment was diverted to that structure. The quantities of material in this dyke are shown in Table VI.

Dyke No. 1 West: Dyke No. 1 west provides closure between the west end of the powerhouse headblock and the high ground to the southwest. The overburden in the area of this dyke consists mainly of a varved silty clay which is successively underlain by a silty sand layer containing sand and gravel lenses, a layer of relatively impervious sandy till of local extent, and bedrock. The permafrost in this area occurred sporadically and it was decided to excavate the overburden to bedrock only for a distance of approximately 100 ft. from the powerhouse. The remainder of the dyke was placed directly upon the varved clay.

The dyke was designed as a homogeneous rolled earth-filled section with slopes of 2.5 to 1 and a large rock toe on the downstream side. The clay fill was obtained from borrow area B and its properties are listed in Table V. It was placed several per cent wet of optimum with densities that were slightly below maximum values. Stability of this dyke was generally not critical in view of its small height, but because of the lower strength of the clay resulting from the wet placing conditions, a 15 ft. wide rockfill berm was added below elevation 595 ft. at the section of greatest height near the headblock. At this junction the clay fill was butted against, and wrapped around, a stub concrete wall extending from the headblock.

The other materials in dyke No. 1 west were obtained from the same sources as the comparable materials in the centre dyke.

The clay fill was hauled in 10 ton and 15 ton trucks, spread by bulldozers, and compacted in 6 inch lifts with 10 ton and 15 ton rubber-tired trucks ballasted to the point where they could just be operated without seriously rutting the fill. Aside from some trouble with locally thawed-out soft spots and poor drainage in the foundation beneath the first lift, no construction difficulties were experienced on this dyke.

The possibility of seepage occurring through the more pervious layers of silty sand with the reservoir filled, was considered sufficiently strong to justify the blanketing of these layered exposures in the overburden slope excavated for the intake channel. This blanket consisted of a 3 ft. thickness of rolled clay fill covered by a 1 ft. sand transition and an 18 in. layer of riprap. Subsequent excavation along the slope showed that these pervious layers were not as extensive as had been originally supposed and the blanket was extended only about 350 ft. upstream from the headblock.

Foundation excavation at the headblock was done in the late summer and autumn of 1958 and stripping of the dyke foundation began in February, 1959. Clay fill placing began in June, 1959, and the trimming of slopes to their final grades was completed in November, 1959. The quantities of materials in this dyke are shown in Table VI.

Dyke No. 1 East: In the area to the east of the sluiceway, the over-

Fig. 8. Typical section through Dyke No. 2 East and Dyke No. 2 West

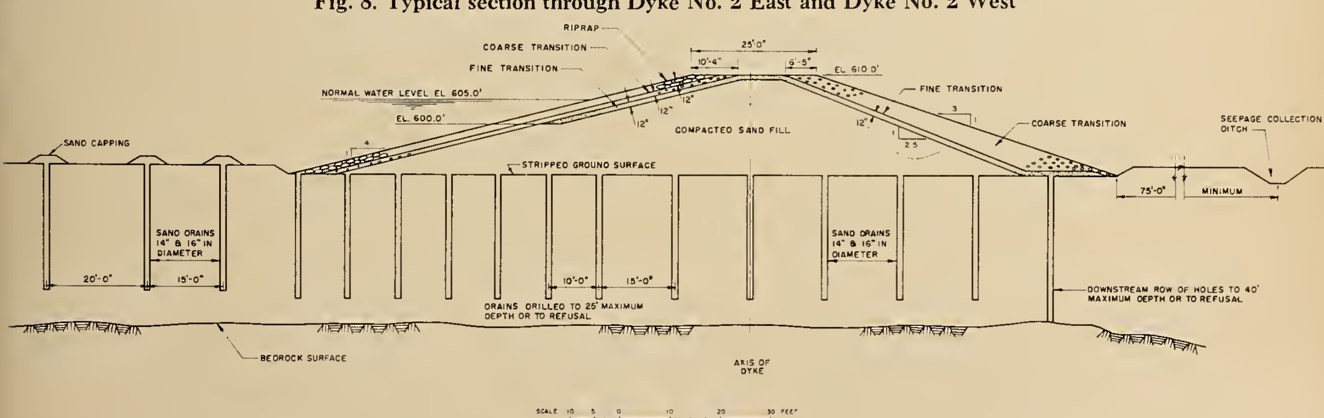


TABLE V

Summary of Field Test Results of Impervious Core Materials in Main Dam, Centre Dyke, and Dyke No. 1 West

	Main Dam			*Centre Dyke*			*Dyke No. 1 West*		
	No. of Tests	*Range*	*Average*	*No. of Tests*	*Range*	*Average*	*No. of Tests*	*Range*	*Average*
Liquid limit (percentage)	35	30–50	37.9	40	32–49	39.1	33	29–57	43.3
Plastic limit (percentage)	35	17–27	20.3	40	13–25	19.9	33	8–26	19.5
Plasticity Index (percentage)	35	11–26	17.6	40	7–27	19.2	33	11–39	23.8
Optimum water content* (percentage)	62	17–27	21.1	37	14–22	19.2	26	18–26	21.2
Maximum dry density* (pcf)	62	96–111	104.5	37	100–112	103.6	26	96–110	99.3
Placement water content (percentage)	152	20–35	26.0= 1.23 x opt	119	9–28	23.4= 1.22 x opt	96	12–31	24.5= 1.16 x opt
Placement dry density (pcf)	152	88–105	95.9= 0.92 x max	119	95–111	101.3= 0.98 x max	96	86–110	96.1= 0.97 x max

*As determined in the Standard Proctor Compaction test.

burden consisted of silty varved clay with a maximum thickness of 30-35 ft. This clay contained extensive permafrost, the progressive thawing and sloughing of which, in the future reservoir, would have constituted a hazard to any structure founded directly upon it. It was, therefore, decided to remove all of the overburden above bedrock for a distance of 465 ft. from the sluiceway to the point at which it intersected the natural 605 ft. contour. A concrete gravity bulkhead was built in this section and dyke No. 1 east provides the closure from the end of the bulkhead to the 611 ft. contour.

Clay fill from borrow area F was used in a homogeneous section which was protected on both sides by a transition zone and riprap. The dyke was constructed in October and November, 1959, at which time difficulty with freezing temperatures was encountered. Excavation of sloughed-in material and placing of fresh clay fill within a heated enclosure was finally restored to, and the dyke was successfully completed in this manner.

Freeboard Dykes: Several very small dykes were required on the west side of the river to provide complete closure to elevation 610 ft. around the reservoir. The maximum height of these dykes is 6 ft. and their total volume is about 5400 cu. yd. As these dykes were all located in low swampy areas where access with conventional equipment during the summer months was difficult, it was decided to construct them in the winter. This was successfully accomplished during February and March, 1958.

The dykes were made of clay fill obtained from small borrow pits located near the dykes. Stripping of the frozen organic surface cover was done immediately ahead of the placing of the clay fill. The fill was obtained and placed in an essentially unfrozen state, although it was found impossible in a winter operation such as this to eliminate all frozen lumps. Those that were included in the fill were broken up during compaction by the bulldozer so that a fairly homogeneous fill was produced. Following the placing of the fill, the stripped organic material was pushed back onto the dykes to provide them with thermal and erosion protection.

Sand Dykes

Design: Approximately 3000 ft. upstream from the dam on either side of the river, there were two low-lying swampy areas which, in order to complete the closure of the reservoir, required the construction of two dykes each about 2000 ft. long and with maximum heights of 20 ft. These are indicated as dykes Nos. 2 east and 2 west in Fig. 2.

At both locations, the surface was covered by a layer of muskeg and topsoil from 1 to 4 ft. deep which made access to the sites very difficult in the summer months. This surface cover was successively underlain by a layer of varved silty clay of variable thickness, a sandy till or moraine layer with maximum thickness of 20 ft., and bedrock. The maximum measured depth to rock was about 45 ft. and the average depth was about 20 to 25 ft.

Permafrost occurred generally throughout both dyke areas in all forms from the fairly plastic type containing minute ice crystals, to the very hard lenticular type containing lenses as thick as 6 in. Numerous pockets of unfrozen soil did occur but, with the exception of two areas near both ends of dyke No. 2 east, these were generally neither extensive nor continuous. The permafrost extended to within 3 ft. of the surface and downwards to, and into, the bedrock.

This permafrost condition extended from the dyke location to within a very short distance of the river, and no suitable dyke line free from permafrost could be established. Consideration had to be given, therefore, to the effect of the creation of the reservoir on the existing thermal regime in the ground that would eventually be submerged. Such considerations indicated that thawing of the permafrost beneath the reservoir is inevitable. Calculations showed that the top few feet of frozen soil will thaw within the first few years of submergence, but that the rate of thawing will progressively decrease with depth. The exact pattern of thawing along the edges of the reservoir is virtually impossible to predict because of the

TABLE VI

Summary of Quantities of Materials in Dam and Dykes

Material	*Dam*	*Centre Dyke*	*Dyke No. 1 East*	*Dyke No. 1 West*	*Dyke No. 2 East*	*Dyke No. 2 West*	*Freeboard Dykes*	*Totals*
Rock fill	94,800	—	—	—	—	—	—	94,800
Transitions	79,300	1,500	1,000	2,800	2,800	3,200	—	90,600
Impervious core	32,000	28,800	1,300	23,700	—	—	5,400	91,200
Supporting zone	82,200	—	—	—	—	—	—	82,200
Riprap / Slope protection / Road dressing	—	1,800	500	4,900	10,100	11,200	—	28,500
Rockfill toes / Filter drains / Sand drains	—	4,400	—	15,500	1,600	2,200	—	23,700
Sand fill	—	—	—	—	33,700	32,700	—	66,400
Totals	288,300	36,500	2,800	46,900	48,200	49,300	5,400	477,400

All quantities are in cubic yards

complexity of the boundary and initial conditions, but there appears to be little doubt that the thawed zone will extend beneath dykes Nos. 2 east and 2 west.

The design and construction of structures in permafrost regions customarily involves one of the following alternative proceedures:

(a) Locating the structure on material which will not become troublesome upon thawing;

(b) Removal of potentially troublesome overburden;

(c) Preservation of the existing thermal regime by natural or artificial means.

In the case of these two structures, alternative (a) did not exist, and studies showed that alternatives (b) and (c) would have been excessively costly and relatively impracticable. These approaches were rejected, therefore, in favour of a design which has no known precedent. This provides for the construction of the dykes upon the existing overburden and incorporates features intended to allow the dykes to accommodate the movements, and to be stable under the conditions that will probably result from the thermal changes in their foundations.

Because of the high ice content in the varved clay, its thawing will produce a large amount of free water and, by virtue of the clay's low permeability, this water will not readily escape. It was considered that the existence of this free water, together with the softening of the surrounding clay to which it would contribute, might result in critical foundation stability conditions, even though the height of the dykes is very small and the surrounding natural slopes are comparatively flat. As the rate of consolidation of the varved clay, subsequent to its thawing, might well be the determining factor in this stability condition, it was decided to facilitate the drainage of the foundation by the use of vertical sand drains.

Beneath each dyke a grid pattern of sand drains was laid out to extend from the downstream toe to a distance of approximately 50 ft. beyond the upstream toe. The spacing of the rows of drains varied from 10 ft. centres beneath dykes greater than 15 ft. in height, to 20 ft. centres beneath dykes less than 10 ft. The drains were 14 in. and 16 in. in diameter and extended to a depth of 25 ft. or to refusal of the drill. In the row farthest downstream, the maximum depth was increased to 40 ft.

The two dykes have identical cross sections, as shown in Fig. 8, and consist of homogeneous fill of compacted sand with upstream and downstream slopes of 4 to 1 and 2.5 to 1, respectively. These are protected by transition zones and coarse rock. The exterior slopes of the dykes are 4 to 1 on the upstream side and 3 to 1 on the downstream side. The use of sand, rather than clay, for the main body of the dyke section was determined primarily by the important advantage that could be gained by building these structures during the winter, when the freezing of the ground cover virtually eliminated the difficulties of access and mobility that would have been encountered by conventional construction equipment in the summer months. Moreover, there was the consideration that a sand fill could accommodate itself to the inevitable differential settlements more readily than could a clay fill.

The sand fill is a pit-run material and the sand transition is a coarser unscreened material selected from the same pit. The coarse transition and filter is a crushed rock grading from 3 in. to ¼ in., and the maximum size of the riprap was about 18 in. The particle-size distributions of these various materials are shown in Fig. 9.

As the slopes on these dykes are appreciably flatter than those required for limiting equilibrium in a granular fill, the only possible sliding failure that can occur is a foundation failure. Such a failure on the downstream side is virtually impossible because the thawing of the permafrost will not extend beyond the downstream toe, nor even reach this area for many years. A foundation failure can occur only on the upstream side and here the safety factor at any time will depend on a number of factors. These are:

(a) The loss in shear strength of the varved clay due to the thawing process;

(b) The rate at which the free water released by thawing can escape;

(c) The rate at which the varved clay can gain in shear strength as a result of consolidation.

Quantitative evaluation of the effects and interrelationships of these factors has been possible only in an elementary form, but the results of triaxial consolidation testing of frozen and thawed soil cores indicate that the consolidation process can be expected to keep pace with the thawing. Under such conditions, it is expected that little loss of strength will occur, and the stability of the dykes will, therefore, be assured.

Settlement of the dyke crests is inevitable and will result from the following four causes:

(1) The escape of the free water produced by thawing of the clear ice in the large voids;

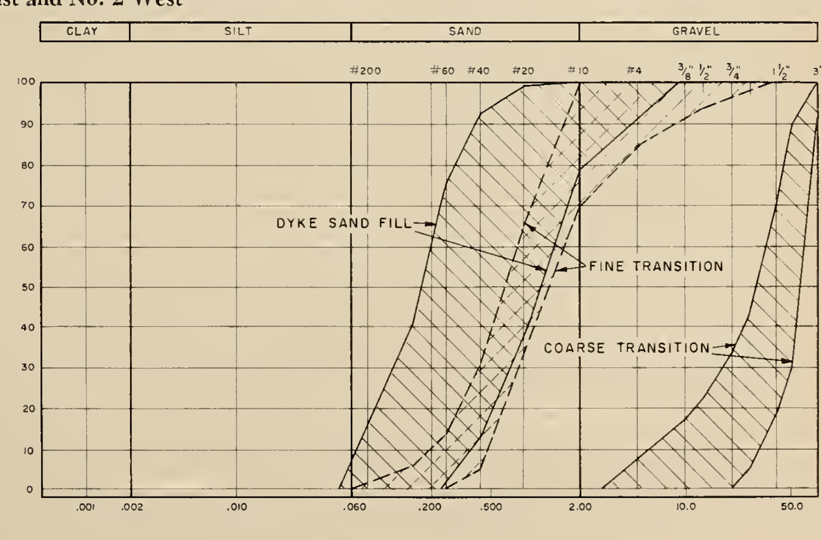
(2) The decrease in volume resulting from the thawing of the ice in the minute voids;

(3) The consolidation of the unfrozen and thawed clay in the foundation;

(4) The consolidation of the sand fill in the dyke.

The total settlement at any point will be largely governed by the depth and nature of the perma-frost at that point and, as these are both highly variable, considerable differential settlements are expected. Estimates indicate that the maximum ultimate settlement will be of the order of 5 ft. As some future maintenance to take care of this setttlement is to be expected, no superelevation allowance was made in the original construc-

Fig. 9. Particle size distribution for sand fill and transition materials in Dykes No. 2 East and No. 2 West



tion. The dyke crests were designed to facilitate future extension upwards, and a stockpile of sand has been provided at the site for such future use.

Because of the highly impervious nature of the varved clay, no foundation underseepage should occur. The comparatively pervious nature of the sand fill will, however, result in steady seepage through the dyke. This seepage has been estimated by flow net analysis and use of a coefficient of permeability equal to 10^{-2}, cm. per sec. to be approximately 0.8 c.f.s. for the entire 2000 ft. of each dyke. Collection ditches were provided on the downstream side of each dyke to facilitate the discharge of seepage into natural water courses, thereby preventing the ponding of it behind the dykes where its presence might disturb the downstream thermal regime of the soil and cause undesirable thawing.

Construction: Stripping of organic matter and topsoil from the dyke foundations was done during March and December, 1958. Almost all of the stripping was done by bulldozer. This operation was difficult because of the hard frozen condition of the topsoil and because of a swampy area at each dyke, which was too soft to support even tracked vehicles. These latter areas were stripped by blasting and with the use of a 1½ cu. yd. dragline.

The holes for the sand pile drains were drilled by two truck-mounted power augers, a 16 in. diam. machine, and a 14 in. diam machine. Approximately 59,000 lin. ft. of drilling was accomplished at an average rate of 38.6 ft. per hr., all of it being done during the winter months with no difficulty. Drilling through the frozen clay proved easy, but a number of the holes were stopped slightly short of their designed depth by boulders in the underlying sandy till which the augers could not penetrate. The drilling statistics are presented in Table VII.

TABLE VII

Summary of Drilling Data for Sand Drains in Dykes Nos. 2 East and 2 West

	Dyke No. 2 East	*Dyke No. 2 West*	*Both Dykes*
Number of holes	1,165	1,456	2,621
Linear feet drilled	24,383	34,578	58,961
Average length of hole (feet)	20.9	23.7	22.5
Rate of drilling (feet per hour)	34.6	42.1	38.6

The holes were filled with sand, similar to the dyke fill sand, deposited in them in a loose state. The drains upstream from the dyke were topped off above ground surface with about a cubic yard of sand each, in order to assure good drainage in future.

The sand fill and sand filter material were obtained from pit siding in the same operation described previously for transitions A and D of the dam. The sand for these various uses was classified and stockpiled according to grading at the pit. After being unloaded from railway cars at Kelsey, it was hauled in 15 ton to 18 ton Euclid and 10 ton tandem trucks to the dykes where it was spread and compacted in 12 in. layers with HD-21 tractors. No measurements of the density of the fill were made, but the compaction methods used produced very dense fills.

Materials for the upstream coarse transition and the downstream slope protection were obtained by crushing of excavated rock and were deposited and spread by bulldozers operating up and down the dyke slopes. The upstream riprap layer was material selected for size from the excavated rock stockpiles.

Excavation of the drainage ditches and channels was done in winter and was accomplished by blasting and the use of a dragline and hand labour. Subsequent sloughing of the slopes necessitated a cleaning out of these channels.

On dyke No. 2 west, the stripping and sand drain construction was carried out in March and April, 1958, and the sand fill was placed in April, 1958, and January, 1959. On dyke No. 2 east, the stripping was done in March and December, 1958, while the sand drains were installed in January and February, 1959. The sand fill in this dyke was placed in February and March, 1959. Excavation of the downstream drainage ditches for both dykes was done in November and December, 1958. The quantities of the various materials used in these dykes are shown in Table VI.

Performance: As the construction of water-retaining earthworks, such as dykes No. 2 east and No. 2 west, directly upon permanently frozen overburden is, to the best of the authors' knowledge, without precedent, considerable interest in their future performance has already arisen. In the hope that careful observation of these dykes will provide valuable data for use in similar problems in the future, a program of instrumentation designed to measure the changes in the thermal regime and the resultant settlements of the varved clay foundation beneath dyke No. 2 east, has been undertaken by the Division of Building Research of the National Research Council of Canada in conjunction with The Manitoba Hydro-Electric Board. The significance of the results being obtained from this program probably will not become apparent for some time, but when it is sufficiently clear to allow a fair appraisal of the performance of these structures, the results will be made available through publication.

Acknowledgements

The design and the supervision of construction for the Kelsey Generating Station were done by H. G. Acres & Company Limited for The Manitoba Hydro-Electric Board. The general contractor for the project was McNamara-Brown & Root. Mr. R. Peterson, acting in an advisory capacity to The Manitoba Hydro-Electric Board, reviewed the designs of the dam and dykes. Helpful discussions concerning the permafrost aspects of the earthworks were given by members of the staffs of the Division of Building Research of the National Research Council of Canada, and of the Arctic Construction and Frost Effects Laboratory of the U.S. Army Corps of Engineers.

The authors are grateful to The Manitoba Hydro-Electric Board and to H. G. Acres & Company Limited for their permission to present this paper, and they wish to thank their colleagues in these two organizations for their assistance in its preparation.

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CHUTE-DES-PASSES 345 KV TRANSMISSION LINE

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The Chute-des-Passes generating station of the Aluminum Company of Canada, Limited, was completed early in 1960 with the installation of the last of five 200,000 hp. units. A 345 kv. transmission system was built to transmit this power a distance of 91.2 miles to the south for interconnection with the existing 2.6 million hp. Saugenay Hydro-Electric System. Design and construction features of this transmission system are recorded in this paper along with data on a new type of aluminum guyed tower that was installed in a short section of one of the lines.

THE storage dams at Lac Manouan and Passes Dangereuses were built in 1940-1943 to provide regulation of the Peribonka River, a main contributor to the flow of the Saguenay River which serves the Isle Maligne, Chute-a-Caron and Shipshaw power plants. This control of the Peribonka River also made power generation on the Lower Peribonka practical, and installation of the Chute-a-la-Savanne and Chute-du-Diable plants followed in 1951-1953.

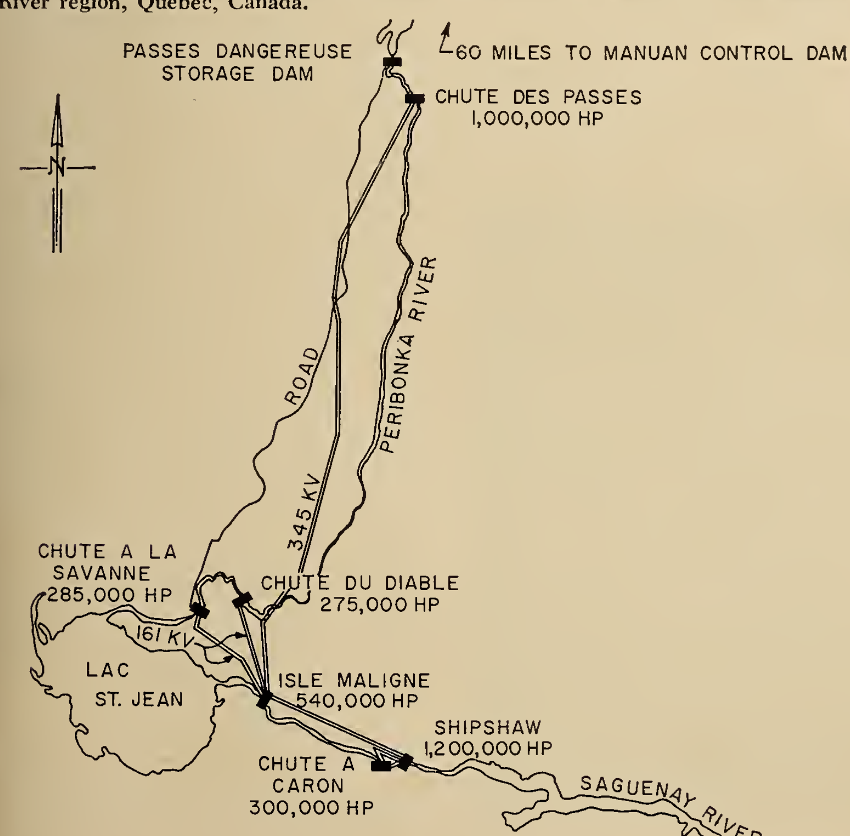
The Passes Dangereuses storage dam has a head of only 135 ft. but by skirting the dam with an 8 mile long system of intake and discharge tunnels, it is possible to add about 500 ft. of static head due to the rapid fall of the river below the dam and develop at Chute-des-Passes a maximum output of about 750 Mw.

System Voltage

The lower twelve miles of the Chute-des-Passes transmission line route between Isle Maligne and the crossing of the Lower Peribonka is through flat and often swampy marginal farm lands with easy access. The remainder of the route varies from mountains to swamps with difficult access.

The full load of 750 Mw. was considered to be too large and important for one tower line in view of the problems of quick access for maintenance and as prolonged loss of the entire load could not be tolerated. On the other hand, transmission at the existing system voltage of 161 kv. would have required an excessively large and costly number of circuits and was ruled out. A system of two double circuit 230 kv. tower lines (4 circuits) was a possibility but was estimated to cost considerably more than a system of two single circuit 345 kv. bundled conductor lines which was selected.

Fig. 1. Map showing principal hydro-electric stations in Lake St. John-Saguenay River region, Quebec, Canada.



Under normal full load conditions, each circuit of the 345 kv. system will carry 375 Mw. with sending and receiving voltages of 370 kv. and 350 kv. With one circuit shut down, the remaining half of the system will be able to carry about 700 Mw. with the addition of some reactive capacity from the remainder of the system. This overload capacity of one tower line of the 345 kv. system was much greater than that of one double circuit tower line of the 230 kv. system being studied, and was an added factor in the decision to go to the 345 kv. system.

Transformation at Isle Maligne will reduce the voltage to 161 kv. for connection to the existing Saguenay network. Due to present reduced power requirements, initial operation of the lines will be at 161 kv. bypassing the Isle Maligne transformer station which will not be built until required.

Radio Interference and Corona Losses

The selection of 345 kv. as the system voltage introduced the question of radio influence or interference, commonly called RI, and the possibility of excessive power losses due to corona generation.

Test data at hand during line design in 1955-1956 indicated that satisfactory RI and corona performance would be obtained from a bundle of two 1.1 in. diam. conductors, spaced 16 in. horizontally and would in fact be equal to or less than that of a single 1.1 in. diam. conductor at 230 kv., a utility standard for many years.

There was also preliminary test and experience data available at the time to indicate that control rings could not be justified at suspension and dead end points and that no special treatment of the conductor surface was required during stringing.

Control rings were not used although all hardware at conductor attachment points was designed so that rings could be added at a later date if initial operation indicates the need for them.

The importance of the RI problem was tempered by the fact that all but the lower short section of the lines lie through uninhabitable terrain and even the lower section is in marginal farm land with only scattered farms.

Conductor Loadings

Although the area north of the Saguenay River and away from the influence of the St. Lawrence River is specified as a low to medium loading area, a heavier conductor loading of ½ in. radial ice and 5 p.s.f. wind at 0°F, was selected and the following limiting conductor tensions were set:

Unloaded initial	at 0°F	less than 33% UTS
Unloaded final	at 0°F	less than 25% UTS
Loaded	at 0°F	less than 50% UTS

The limiting conditions for each of the two ruling spans of 1400 and 1650 ft. was the final unloaded tension of 25%, although for both spans the loaded tension reaches very close to the 50% limit.

Conductor Design

In the evaluation of optimum conductor aluminum area versus value of power losses, values of from $0.60 to $2.00 per thousand circular mils (MCM) per phase mile were added to the basic conductor cost to represent the incremental costs of towers, footings, transport, erection and stringing that can vary with a change in conductor size.

This study indicated an aluminum area per sub-conductor of from 800-900 MCM and the RI study mentioned above pointed to a conductor diameter of approximately 1.1 in.

A 45/7 stranding ACSR of 850 MCM aluminum area, with a rated ultimate tensile strength of 23,900 lb. and a diameter of 1.099 in. was selected and appeared to provide the lowest overall line cost.

In anticipation of a possible future increase in transmission line load, all towers and suspension assemblies were designed so that a third conductor can be added to the present bundle of two, thereby increasing the transmission capacity of the system without addition of a new tower line.

Insulation and Hardware

Suspension assemblies consist of a single string of eighteen 5¾ in. by 10 in. porcelain or glass 25,000 lb. M. and E. strength insulators, with a simple yoke at the lower end for attachment to the suspension clamps.

Fig. 3. Spring type spacer.

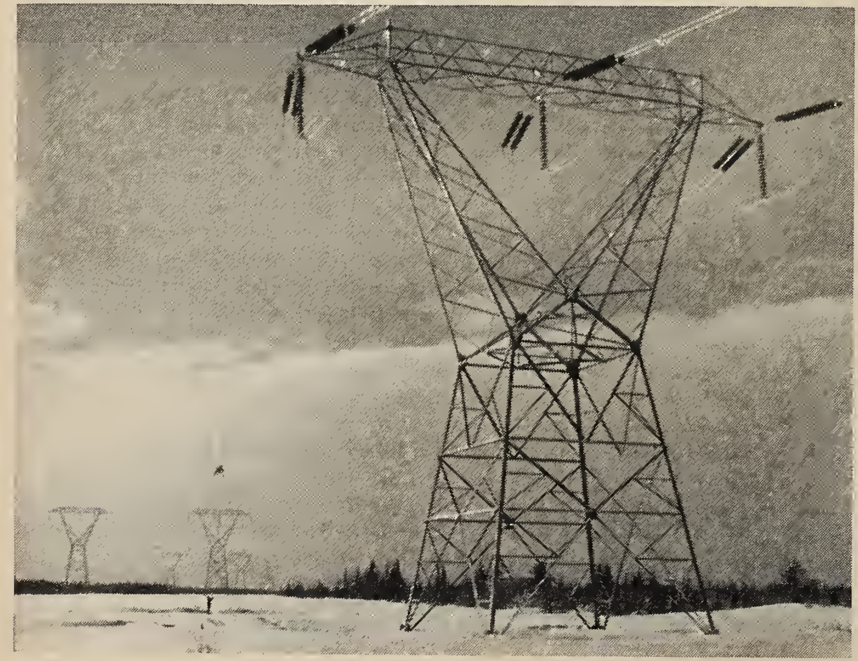


Fig. 2. Deadend assemblies on 20° strain tower. Note mid-span installation of spacers.

The deadend assemblies shown in Fig. 2 have a single string of 20 insulators for each conductor, the extra two units being expendable to permit installation of the longer yoking hardware that will be necessary if a three conductor bundle is ever installed.

A 6 in. turnbuckle was placed at the tower end of each insulator string to permit correction of any minor errors in the deadening operation. This adjustment was only used at about one deadend tower in four and the amount of adjustment never reached the full range available from the two turnbuckles. Omission of one of the turnbuckles might be warranted in the future.

Conductor Hardware

Tubular type compression joints and deadends were used throughout. Conductor support points were reinforced with formed armour rods and Stockbridge dampers were placed at each end of each span of conductor.

Recent experimental and field test work by others has indicated rather convincingly that vibration of bundled conductors is usually less than that of single conductors. It was not considered advisable to omit vibration dampers on these lines, however, as the evidence was not conclusive at the time of stringing and, as shown above, everyday conductor tensions are not low enough to justify the risk of such full scale experimentation.

Conductors are positioned in the bundle with a spring type spacer (Fig. 3) that permits restrained movement in any direction but has no moving parts to wear. The clamp action produces a good grip on the conductor and permits easy mid-span installation as there are no loose nuts, washers or small pieces to handle.

The first spacers were placed 50 ft. from the tower and out in the span were set a minimum of 225 ft. and a maximum of 300 ft. apart.

Protection and Communication

The power line carrier system has four parallel 20w. single-sideband links providing duplex voice communication with superimposed audio frequency shift channels for transfer

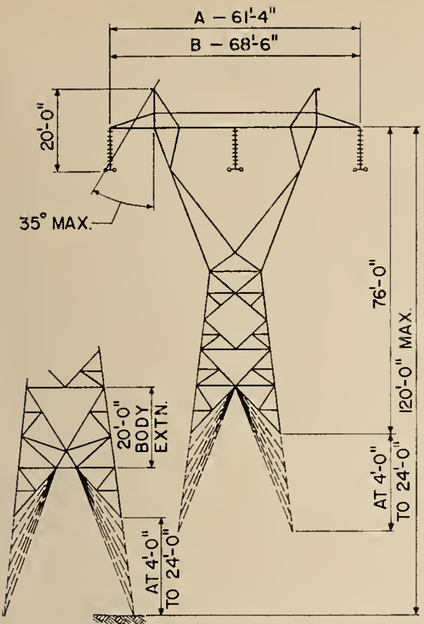


Fig. 4. Outline dimensions of A and B suspension towers.

trip protection relaying, telemetering and teletype. Two of these links are coupled phase to ground of phase A of one line and two to phase A of the other line. The equipment is coupled to the lines by 400 kv. coupling capacitors which also act as potential devices. A 2000 amp., 0.165 millihenry band-tuned wave trap is used at each coupling point.

The use of multi-purpose carrier equipment with a gross band width of 4 kc. in each direction permitted a most reliable arrangement by carrying the protection relaying channels in parallel over two separate links. A relaying signal for one of the two transmission lines is thus always transmitted over both transmission lines.

The 4 duplex voice links, 2 duplex relaying channels, 1 duplex teletype channel, 3 continuous telemetering channels and 1 simplex voice channel between either terminal station and a mobile carrier set only occupy a total gross band width of 37 kc. Each of the 4 links occupies 8 kc. for both directions and each link permits allocation of several additional narrow band channels above the voice band for future requirements.

The high speed distance relays work on a modified impedance principle on phase as well as ground faults. Each protection terminal consists essentially of one one-cycle relay for instantaneous one-zone coverage and one relay for multi-zone back-up protection. Faults outside the instantaneous zone of one terminal are detected and relayed over the carrier system by the opposite terminal.

Operation with single phase and/or three phase high speed reclosing or operation without reclosing can be selected by means of a switch located in the relay panel. Phase selection in the case of the single phase reclosing with carrier tripping is provided by the impedance starting elements under-voltage relays. Mechanical targets and remote annunciators assist in analysing faults.

The line breakers at each end are the air blast type with a rating of 2,000 amp., 15,000/18,000 MVA three phase interrupting capacity, with a BIL of 1,550 kv. Initially, the lines are to be operated at half-voltage, obtained by connecting the high voltage windings of the transformers in parallel. This connection allows the use of only the highest off-load tap and the bank ratio is then 13.8-192.5 kv. and the test BIL of the high voltage winding is 750 kv.

The transformer banks are protected by lightning arrestors with a rating of 308 kv.

Ground wires of ACSR Partridge conductors are carried for about one mile at each end of the lines to protect the terminal equipment. The low isokeraunic level of the area indicated they could be omitted for the remainder of the lines, although all towers were designed and detailed so that ground wire horns can be added in the future.

Tower Loadings

Three types of towers were used with the loading limits shown below:

Towers and footings were designed

	Number in Line	*Wt. Span*	*Wind Span*	*Max. Line Angle*
Suspension A	298	2400 ft.	1600 ft.	1°
Suspension B	272	3000 ft.	2000 ft.	3°
Light Angle Strain	32	3000 ft.	2000 ft.	20°

for the loads resulting from a triple bundle of loaded conductors in applications as stated above, all with a factor of safety of 1.5. Both A and B suspension towers can also carry vertical overloads of 40%.

A longitudinal or broken wire loading of 65% of the unloaded final 30° tension of the three conductors in the bundle was applied at any one suspension point of the A and B towers, combined with vertical and transverse loads resulting from no ice and 3 p.s.f. wind on the conductors, all with a factor of safety of 1.5.

The 20° strain type towers are designed for longitudinal loads at all three attachment points equal to 16,000 lb., which approximate unloaded conductors in the span on one side of the tower with no conductors on the other side or loaded conductors on one side and unloaded on the other.

An additional wind load of 20 p.s.f. was applied to one face of the towers loaded with ½ in. ice coincident with the maximum ice and wind loads on the conductors.

Construction

A 115 mile system of bush roads had to be built for the sections of the transmission line that were not served by the local roads or the main project road.

During the winter months, line materials and heavy equipment were moved easily with trucks, tractors and sleds and the lighter haulage was done with snowmobiles, muskeg tractors and jeeps.

Once the snow roads disappeared, transport was limited to tracked equipment and the terrain was so rough, and swamp and muskeg sections so extensive, that only very slow speeds could be maintained and the equipment required extensive maintenance.

Reference to the Construction Progress Chart, Fig. 5, will show that a major part of those items requiring heavy transport of men and materials were concentrated in the winter months. The experience on the project indicates that with such a road system in similar difficult terrain, an even greater portion of the work might well be attempted during the winter.

The contractor established his main camp and material yard at the Isle Maligne railhead at the southern end of the line, and a second semi-permanent camp, complete with equipment repair facilities, was set up adjacent to the main road near the mid-point of the line.

Two other camps were set up at quarter points and between these temporary camps moved with the work.

Clearing

The normal clearing requirement was for a 300 ft. strip that permitted 75 ft. on the outside and 150 ft. between the two lines of towers. Trees outside these limits which were so high that they could strike the conductors in falling were classified as danger trees and were also cut.

Stumps of 12 in. were permitted and all brush and logs that were not merchantable as pulp wood had to be burnt or removed from the right-of-way with the exception of logs of more than 15 in. diam. which could be cut in 10 ft. lengths and left to rot in contact with the ground.

Material Transport

Ninety percent of the tower steel was scheduled to arrive at Port Alfred on the Saguenay River before freeze-up in 1957 and this was yarded and sorted and then delivered along the line to the individual tower sites during the following winter.

A small tonnage had been retained for Spring 1958 delivery to accommodate last minute changes of requirements and this was taken to site at the northern end of the line during the following winter.

Conductor was shipped at regular intervals through the winter of 1957-1958 and immediately dispersed along the line. The reels were carefully grouped according to length and as the reel length was nominally 7850 ft., caches of 24 reels were established approximately three miles apart to permit pulling both ways on both lines from the same point.

Insulators and hardware were distributed to the tower sites at the same time.

Footings

The steel grillage for normal soil conditions was a quadruped shape utilizing a technique of assembly requiring few bolts which is best described by reference to Fig. 6.

Rock anchorages consisted of a steel weldment on a small concrete pad and held down by a set of four bolts grouted into the rock. Split wedges at the lower ends of the bolts were used to increase pull-out resistance.

Unfortunately, ground conditions were such that straight forward installation of footings was possible at less than a third of the tower sites.

Water was encountered at more than 70% of the footings, and where a permanent high water table was indicated, a pattern of 8 ft. long red spruce logs was laid across the top of the grillage to increase the volume of soil above the grillage and counteract the decrease in uplift resistance brought about by buoyancy.

Very poor bearing values were obtained at several sites and at one, where suitable resistance to drilling could be obtained at about 30 ft., timber pile footings capped with concrete were used. At other sites where piles would have been 90 ft. in length or more, timber mats up to 16 ft. square were used to reduce the pressure on the soil to values found suitable by tests.

The installation of rock footings was complicated by the large quantities of shattered rock found when footings were opened up. Where extensive, the broken rock was removed and a grillage installed.

Surface examination of the tower sites proved to be a very unsatisfactory aid in scheduling equipment

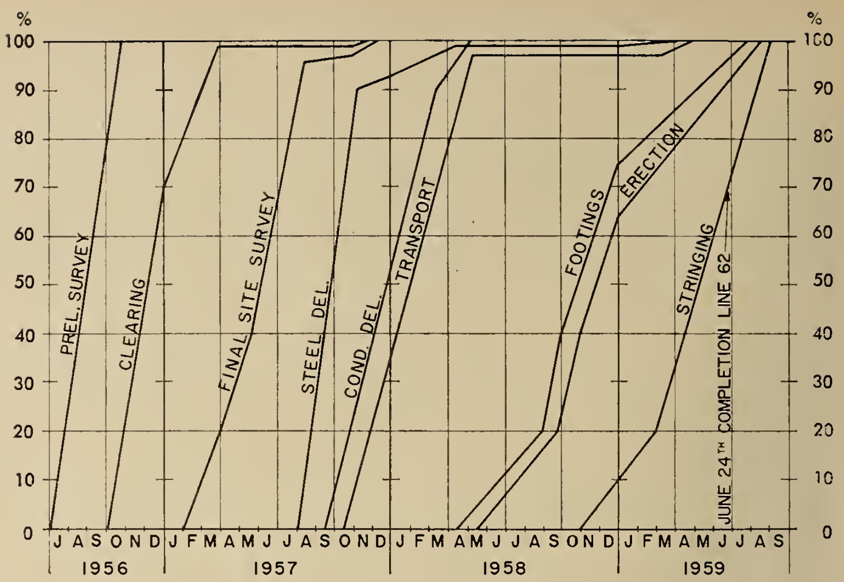


Fig. 5. Construction Progress Chart.

deployment. Frequently a backhoe was set to work to open what appeared to be a standard grillage excavation, a compressor and drill would be moved in to break up loose rock or boulders too large to remove whole and then a ledge of solid rock would be encountered requiring further drilling and the erection of a rock footing on a concrete pedestal.

This led to considerable interchange of grillages and rock anchors from tower to tower and the original dispersal of leg extensions, based on individual tower site surveys, had to be changed frequently as the footing work proceeded.

Footing installation continued at a reduced rate through the winter. Temperatures reached —55°F but an early heavy snow fall proved to be sufficient insulation to limit frost penetration to from one to two feet.

In setting grillages in the winter an attempt was made to complete excavation, setting and backfill in one day so that the backfill material did not freeze. Care was taken to ensure that the material below the grillage did not freeze before setting and that no snow, ice or frozen material got mixed in the backfill. The latter was not always possible and in the early summer a cleanup crew went back to such towers to bring the backfill up to grade. No cases of heaving of footings before or after tower erection were reported by the inspection personnel.

Materials for concrete work on the rock footings required heating. Concrete additives were used to create added heat during set-up and when combined with the use of rock-wool insulating bats and wind protective covers, good curing of the concrete was obtained.

The problem of the "Peribonka Sands", peculiar to the area, forced the contractor to produce his own concrete aggregates for a considerable section of the line. Methane gases, released from underlying beds of decaying organic materials have over the centuries risen into the surface deposits of sand and gravel and coated the grains with a product that dissolves during the making of concrete. An unpredictable and damaging degree of aeration occurs that can be chemically controlled on large concrete operations but which is almost impossible to combat on small quantity work such as tower footings where there is frequent opening of new gravel or sand pits as the crews move along the line.

Tower Erection

The towers were pre-assembled by a crew that worked about 2 weeks ahead of the erection crews. Side panels of the body of the tower, the two arms and the complete crossarm were ground assembled.

The following 9 man erection crew, equipped with a 72 ft. sectional aluminum gin pole, could, where the terrain was favourable, erect more than two 96 ft. towers in one day. Difficulty in guying the gin pole and very uneven terrain that made it impossible to locate the pre-assembled sections in good positions for raising could cut the efficiency of this operation greatly.

A follow-up crew accompanied by an Alcan inspector later checked every tower to ensure that all nuts were tight and that all threads were punched.

Before the onset of winter, the pre-assembly crews were increased so that a heavy snowfall would not cover the piles of tower material.

However, the very good progress of the stringing crews following close behind made desirable the winter erection of a greater number of towers than originally scheduled. A considerable amount of steel for these extra towers could not be found and replacement material had to be drawn from the yards. Cleanup crews in the spring picked up the lost material which was used in the last 80 towers that were erected during the summer of 1959.

Fig. 7. Mid-winter stringing operations.

Stringing and Sagging

The stringing specification did not call for special treatment of the conductor surface and techniques satisfactory for stringing 795 MCM ACSR for 230 kv. were considered adequate. At his option, the contractor decided against tension stringing in favour of the method of pulling the conductor along the ground, using timber lagging where necessary to prevent damage to the outer aluminum strands. About 75% of the stringing was done while there was sufficient snow to minimize the danger of conductor damage and cut down on the placing of lagging. Two 50-60 man stringing crews were employed. The first started near the lower end late in 1958 working north and the second crew started in mid-February 1959, working north from near the midpoint of the line.

The group pulling out and stringing conductor worked from 1 to 3 weeks ahead of the sagging-in crew. The conductor was pulled up to about 60-70% stringing tension so that it was well free of the ground and in no danger of getting 'frozen in'. An allowance for creep during this time in the air before sagging-in was made and added to the initial sag data. This creep correction was standard for all spans and contained little error as long as the period in the air while awaiting sagging-in was more than 3 days and less than 3 weeks.

The only exception to this was during the stringing of the very first section of line south from the Peribonka River in November 1958. The first 4 miles of conductor in one line was off the ground and 2 miles of this had been sagged-in and checked when a severe ice storm hit the area depositing a 1 in. thick coating of clear ice on one side of the conductors, a load of approximately 0.7 lb. per ft.

A recheck of sags on the sagged-in portion indicated an increase of from 2.5 to 3.0 ft. which checked very closely with that to be expected from such a loading. The contractor was then told to make a similar compensation when sagging-in the other conductor that had been in the air awaiting sagging-in.

A wind of from 20 to 30 m.p.h. that followed this ice storm produced galloping on one phase of one span of the sagged-in section. A vertical movement of from 6 to 9 ft. in three loops at about 40 cycles per minute was observed. The two conductors of the bundle, that were already fitted with spacers, moved together and maintained their horizontal position at all times.

In order that the conductors of a bundle should maintain equal sags after being sagged-in it was necessary to ensure that they both had the same stress histories before sagging. The contractor always handled the conductors of a bundle at the same time and under approximately the same tensions, and checks of the sags up to 12 months after sagging have disclosed no new differences between the sags of the bundle.

Precision control of the sagging was obtained by use of small high ratio manually operated winches that were clamped to the legs of the tower at one end of the sagging section. Within 10 days of sagging, a follow-up crew installed dampers and spacers.

Fig. 6. Quadruped grillage being set. Bearing angles are placed in the triangular slots in channels. Broken rock is typical of conditions encountered at tower sites.

Aluminum Guyed Towers

During initial studies, consideration was given to the possibility of using guyed mast type suspension towers. They were rejected in favour of conventional rigid towers as the project schedule did not afford sufficient time for the thorough investigation necessary for such a radical departure from standard North American practice.

The investigation of guyed towers continued, however, and before completion of the project, authorization was given for the design, fabrication and testing of one full scale prototype of strength and size equivalent to the A type rigid tower. The program of tests, described briefly below, proved the structural adequacy of the towers and four towers, three 76 ft. to crossarm and one 97 ft. to crossarm, were installed in the lower end of one of the Chute-des-Passes circuits, and have been carrying power since September 1959.

Design

The two masts and the crossarm were fabricated of B51S-T6 structural aluminum alloy (Am. des. AA6351-T6) with the following design stresses:

Tension = 26,000 p.s.i.
Compression = 25,000 − 140 $k(1/r)$
to be $\leq$24,000 for $k(1/r) < 64$

$$\frac{6.6 \times 10^7}{(k1/r)^2} \text{ for } k1/r > 64$$

Where k is an end fixity factor.
Bearing = 35,000 p.s.i. on 1.25D edge distance to
50,000 p.s.i. on 2D edge distance

Plain extruded equal leg angles were used for many of the members but special shapes were designed for the principal compression members. A bulb angle was used for the main struts in the masts and a lipped channel in the lower chord of the crossarm. All nuts, bolts and washers are galvanized steel.

The mast is made up of sections 21 ft. long weighing 170 lb. complete with bolts.

The aluminum in the 97 ft. tower weighs 2755 lb. to which must be added the nuts and bolts, guys and anchorage material which are of steel.

The main tower footing is a 5 ft. by 7 ft. rectangular grillage buried 6 ft. to ensure security from frost heave. The only loads on this footing are thrust and shear with no possibility of uplift.

Guys and Anchorages

The guys consist of a stranding of 19 wires of 0.1052 in. diam. aluminized ACSR core wire with an OD of 0.526 in.

A double guy is used passing around a thimble at the top end and the two guys are then twisted about each other to eliminate the possibility of vibration trouble. Each guy wire is terminated with a compression sleeve.

When sound rock is present, guys are anchored to an eye bolt grouted into place. The threaded U-bolt arrangement is used for final adjustment and pretensioning of the guy wires.

A variety of types of guy anchors for normal soil conditions have been considered and at the present time, dished and flanged steel boiler ends appear to be satisfactory and they are the least expensive of any alternatives considered to date. They can be obtained in a range of diameters and thicknesses to suit the guy loadings. A long U-bolt is used as a guy rod and threads at the upper open end permit adjustment of the guys as with the rock anchors.

Test Program

Compression tests were carried out on complete legs to determine the behaviour of the joints and suitability of the bracing system as applied to columns of these proportions.

A 103 ft. 4 in. leg, weighing 8.5 lb. per ft., carried a compressive load of 80,000 lb. without failure and a shorter leg of 82 ft., composed of the same elements, reached 93,000 lb. before failure.

A complete tower, 76 ft. to crossarm, was then erected on a rocky site near Arvida, Quebec, and subjected to loadings equal to 1.5 times the design loads. Difficulty was experienced with details at the conductor attachment points but these were readily corrected.

The full vertical and transverse loadings were carried with no signs of distress in the tower. Failure did occur at 135% of the design longitudinal load in a member of the mast

Fig. 8. Erection of 76 ft. guyed tower.

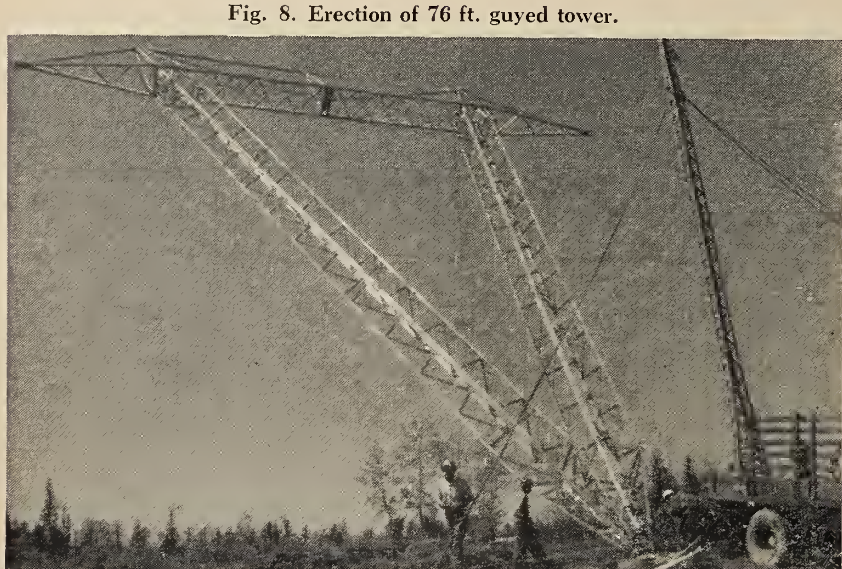


Fig. 9. Guyed aluminum tower—76 ft. to crossarm.

section between the crossarm and the point of attachment of the guys. The arrangement of members at this point has been changed in later designs of the tower.

A series of tests on uplift capacity of large guy anchors embedded in a variety of soils at varying depths has been started and will continue.

Creep of anchors is being measured on two of the line towers that were located in a swamp. Guys of these towers received pretensioning and levels of the tops of the anchor rods and the grillages are being recorded periodically.

In order to obtain a better impression of the stability of the tower, a guy was removed from one of the four line towers after stringing was completed. Adjacent spans were 1150 ft. and 1550 ft. A transverse load of 2,400 lb. (equivalent to a 3°—4° line angle or a wind of 45 m.p.h.) was applied to the tower on the opposite side of the removed guy. The unrestrained end of the crossarm moved less than 2 ft. along the line and about 6 in. across the line. This small movement is a good indication of the restraint offered by the conductors and ground wires.

Acknowledgements

Engineering and construction were under the direction of the engineering staff of the Aluminum Company of Canada, Limited, Mr. F. T. Matthias, Director of Engineering and Construction. Mr. D. H. Logie contributed to the section on Protection and Communication. Power Lines Construction Limited were principal contractors for the construction of the transmission line. EIC

AUTOMATION IN THERMAL POWER PLANTS

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In the operation of both thermal and hydraulic generating stations Utilities have long been leading users of automatic controls. These have been applied both to control the quality of the finished product, electrical energy, and to control the mechanical parameters of the plant. Thermal generation is of course the more complex process, and we have gone a long way since hand fired boilers and manual control of combustion and feedwater could be relied upon to raise steam.

THE BASIC automatic controls which have been developed to a high level of efficiency are —

(1) Combustion control;

(2) Feedwater level control;

(3) Steam temperature control;

(4) Speed governor;

(5) Voltage regulator.

(1), (2) and (3) have the main responsibility for the safety and economic operation of the thermal portion of the plant while (4) and (5) control the quality of electrical output. There has been a recent trend to the use of electrical controllers for (1), (2) and (3) in place of pneumatic devices.[5] In this field of power generation it is clear that automation is no stranger.

Utilities have also been quick to take advantage of progress in other fields, notably in the use of automatic computing facilities. Network and transient analysers have long been used but more recently the availability of high speed digital computers has found ready response amongst utility engineers as is shown by the approximately 200 digital computer programs recorded in ref. (3).

These programs include such items as transmission line performance, economics of system expansion and system operation, structural design of transmission lines, load forecasting and steam station heat balance and incremental heat rate. This paper will review the progress being made in combining the best features of existing automatic controls with the powerful features of digital data handling equipment to take another large step forward in improved operation of thermal generating stations.

Analog and Digital Measurement & Control

It would be well at this stage to clarify the two main classes of measurement and control. Most conventional controls operate on an analog basis. This means that a quantity is represented by a physical variable such as rotation, translation, voltage, or resistance. This analog may be used to record for example on a chart recorder or it may be used in conjunction with other analog quantities to carry out a computation and produce a resulting analog output for actuation of a control. An example of the latter is the three element feedwater control which uses analogs of steam flow, feedwater flow and drum level to produce as output a signal to adjust feedwater flow control valves. The digital approach is to represent a quantity by a number in some suitable system, decimal or otherwise. Any necessary computation is carried out on the number or numbers. The raw data will often be in analog form and must be converted to digital form. The output may be in digital form punched on tape or typed.

Where the output is used for control purposes it may be convenient to restore the quantity to analog form. We will consider later how the choice may be made between analog and digital methods for measurement, recording or control in a given case.

Computers for Control

While digital computers of various sorts have been used for a considerable number of years for processing a variety of business data and for engineering design purposes, it is only recently that this type of equipment has found a place in industrial process control. This may at first seem strange since many control problems can be expressed in mathematical terms and solved by a calculating machine. To carry out complex procedures the equipment must be able to carry out a programmed sequence of calculation which it has remembered. For business and engineering purposes a computer is presented with instructions and data in numerical form usually on cards or punched tape. This is stored in a memory and, after completing the calculation, the answers are fed out again in numerical form on punched cards or tapes. If occasional maintenance is required this can be done at prescheduled hours. A failure of equipment may be an annoyance but aside from delaying computation and possibly requiring the re-run of the program in progress at the time of failure, no harm results. Thus many computers used in business and scientific work do require appreciable amounts of maintenance and checking time and employ hot cathode tubes which require routine replacement. Often, too, business calculations involve handling large volumes of data and performing comparatively simple mathematical processing. The amount of data and instructions to be stored by the machine may be comparatively small for any one program and when a new problem is to be solved the machine can have a fresh set of instructions loaded in. If one computer will not handle all the work, this can be shared between two or more.

If we are to use digital equipment for control purposes much more stringent requirements must be met. Since a process may operate 24 hrs. a day, 7 days a week without shutdown for long periods, so must the computer. Speed of computing is no longer simply a question of the economics of how much one computer will handle but of keeping up with the process and doing all of the necessary calculation in a time limited by process characteristics.

All of the necessary information and instructions must be available in the computer memory for every phase of its operation. Data is not available directly in numerical form but must be obtained by the computer from sensing devices which measure process parameters and which provide analog quantities which must be converted to the computer language of "bits" or "digits".

These differences in requirement have led to the development of computing equipment specially designed for industrial process control. This equipment uses static devices throughout and components used at only a fraction of their rating in order to achieve reliability of the highest possible order. Facilities are incorporated for the computer to read analog quantities representing process parameters. Large memory capacity permits storing large quantities of recorded data and instructions which are required.

High operating speeds are necessary both in carrying out calculations and in gaining access to information stored in memory. On the other hand accuracy in the order of 1 part in 1000 will usually be adequate to match accuracy in available measuring devices. More than 3 significant decimals may be necessary to ensure accuracy through calculation procedures but the use of 10 decimal digit accuracy common in business computers may be unnecessary.

Constructional techniques and component design are tailored to suit industrial environment conditions rather than the "ideal" environment often afforded to other types of computers. Only recently have components, particularly the transistor, become available to meet these exacting performance and reliability requirements for industrial process control computers.

Computers in Thermal Generating Stations

A thermal station is an example of a complex industrial process for which such computers have been designed. That this process is already largely automated has been mentioned earlier but we can note the following manual processes which are still carried out in most existing stations.

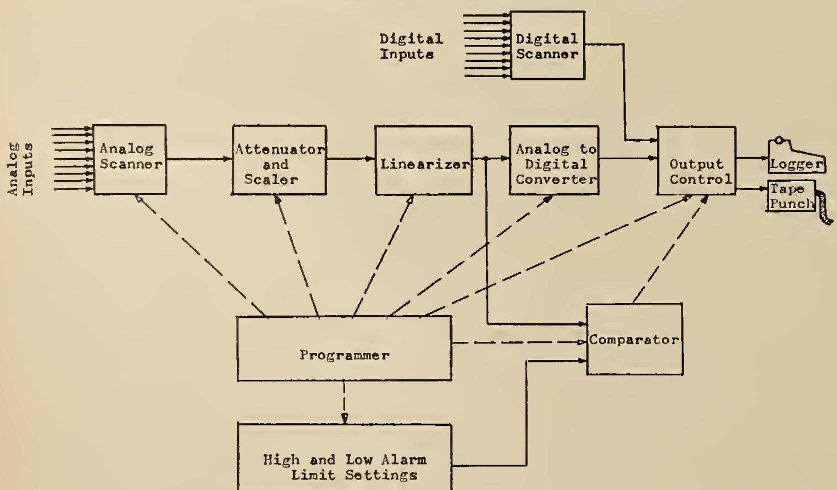
(1) Much of the operating data is still collected by hand logging of instrument readings. This collection of data serves as a means of regular supervision of process conditions as well as providing historical data.

(2) The results from logged readings together with information extracted from chart records is manually processed to give performance information such as overall heat rate and component efficiencies.

(3) Minute-to-minute supervision of the plant combines a check of readings of a few vital quantities, together with review of the more occasional data which is logged. In addition a variety of quantities is provided with alarm annunciation from relays or other devices.

(4) Further to the functions above relating generally to steady state operation the operator must perform a variety of functions and provide special supervision during process changes such as start-up, load increase or decrease, and shut down of the unit.

Fig. 1. Block Diagram of 310 Data Acquisition System



Improvements in station design have generally led to concentrating vital instrumentation in a central control room and to the unit approach to generator and boiler construction. By this means the operator is presented with all pertinent information within easy reach. This has made possible not only the improvement in the quality of supervision needed for modern high performance station equipment but also the reduction in total manpower requirements.

Data Logging

Taking the manual functions listed above in the order given, computer techniques are being applied to take over these requirements.

Fig. 1 shows in block diagram form a data logging equipment designed to take over the manual logging noted in paragraph (1) above. The data is obtained from suitable sensors similar to those used for analog measurement. These provide a millivolt or other signal equivalent to the primary quantity and this is converted into digital form which suits the handling process and output. A program in the data logger controls the scanning of quantities to be recorded. The program is arranged also to provide the necessary scale factors to suit various full scale inputs from sensors and if necessary to linearize inputs from sensors such as thermocouples. This permits the digital output to be in engineering units and the quantities are typed out on a logging typewriter as required or on a regular timed basis such as every hour.

Data loggers can also be readily arranged to provide alarms when a quantity exceeds or falls below the preset limit specified for each point. Scanning for alarm purposes is done frequently and for example a data logging system of 100 points could scan each quantity every 10 to 20 sec. Print-out of information will occur only when a point exceeds its assigned limit or when complete print-out is called for at regular intervals or on demand by the operator.

Equipment used for data logging and alarm is not strictly a computer since it does not include arithmetic facilities or memory except in the limited sense of its program. This may take the form of a pin board programmer as illustrated in Fig. 2. The data logger has thus taken over the manual fnuctions listed under item (1) but with the following improvements.

(1) The log is available in more legible and accurate form;

(2) The log can be recorded ac-

curately during periods of system or equipment disturbance when the operator may be distracted by more urgent tasks;

(3) The degree of alarm supervision is close to that provided by individual alarm relays and individual annunciators for each point and far superior to the supervision associated with manual logging;

(4) Annunciator and indication or recording instrumentation costs and space requirements are reduced.

Since much of the collected data is of historical interest only, the operator can confine his attention primarily to the alarm information which is listed on an alarm printer separate from the logging typewriter. This extends the existing trend of giving the operator only the essential minimum of data.

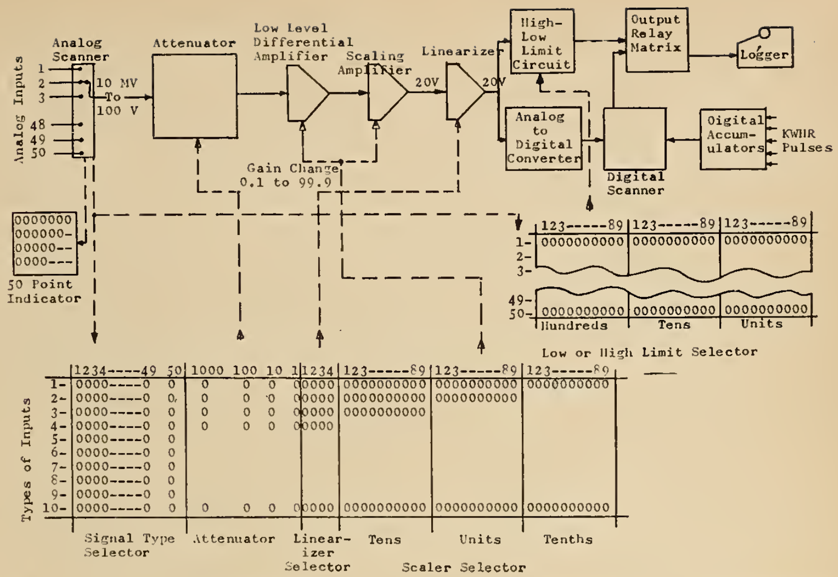


Fig. 2. Functional Diagram of the 310 Data Logging System With Its Pinboard Programmer

Performance Calculation

When historical data is used to calculate performance this can be done manually from the typewritten log in the same way as is commonly done from the handwritten log. Programs have been developed (Ref. 3) to make performance calculation on business type computers which may be available in the plant or elsewhere. In this case it may be convenient for the data logger to prepare a punched tape which can be processed directly as computer input.

An alternative arrangement is to use an industrial process computer associated directly with the generator unit to combine the functions of data logging and performance calculation. The initial advantage of this arrangement is that, with the facility of rapid calculation, the computer can make available performance results at regular intervals within a second or so of the end of the period reviewed. This may be done on an hourly and daily basis. This in itself is enough to justify the extra equipment on a large unit but of equal benefit are the extra facilities which can be provided with the high speed arithmetic abilities and memory capacity of a computer. Alarm limits need no longer be fixed by operator's selection but may be programmed as a function of some process variable such as load.

The computer can also be instructed to scan points at varying rates depending on the importance of the measured variable. Speed of alarm scanning and comparison with limits is raised to hundreds per second. Storage in memory provides the necessary buffer to allow printout of alarm and logging information at speeds within typewriter capability without interrupting the other scanning and calculation functions. Thus logging speed is no longer limited to typing speed as with a simple data logger. Alarms for calculated quantities can be provided as for example when heat rate falls below a reasonable value for the operating conditions.

Typical performance calculations used for a turbine-generator unit are:

(1) Overall Boiler-Turbine-Generator Heat Rate;
(2) Turbine-Generator Heat Rate;
(3) Boiler Efficiency;
(4) Monitor Extraction Feedwater Heaters;
(5) Condenser Performance;
(6) Air pre-heater, economizer monitoring;
(7) Generator field temperature from field volts and amp.

With such calculations the computer reviews overall performance of the unit and also checks individual component performance for deterioration. These results are available rapidly so that corrective action on components or operating practice can be taken to improve operating efficiency.

The computer scans and stores the quantities required to calculate performance. In the memory are loaded the calculation instructions and such basic data as steam tables which are necessary during the calculation. Quantities used in performance calculation are scanned every few minutes and averaged over the review period such as one hour.

It will be helpful to consider two of the performance calculations in some detail to illustrate the procedure. In calculating boiler efficiency the input-output method could be used. This involves measuring the quantity of fuel and for gas and oil fired stations the available flow measuring equipment is not ideal. Coal fired stations present an even greater problem in accurate weighing particularly over short periods such as one hour. A more suitable method based on the ASME Boiler Test Code is the heat loss summation procedure for boiler efficiency; this is recommended for computer calculation. The losses are estimated on a B.t.u./lb. of fuel basis. Efficiency is calculated

$$\text{from} \left(1.00 - \frac{\text{lost B.t.u./lb.}}{\text{B.t.u./lb.}} \right) \times 100\%$$

The computer is supplied with B.t.u./lb. based on fuel sampling. Losses included are:

a) Heat loss in dry gases (based on gas temp. - air temp.);
b) Heat loss due to moisture (based on sampled moisture per lb. and measured gas temp.);
c) Heat loss due to hydrogen;
d) Heat loss due to CO;
e) Heat loss due to combustibles in ash;
f) Heat loss due to radiation (stored in computer as table based on gross heat input).

With a small empirical addition for unaccounted losses the total loss is used for boiler efficiency without the necessity of fuel weighing. Another advantage to this method is that errors in loss estimates have only a second order effect on calculated efficiency.

Turbine generator efficiency calculation illustrated in Fig. 3 shows that net turbine input is measured at points of heat transfer between boiler and turbine. Pressure and temperature sensors plus steam tables stored in memory provide the computer

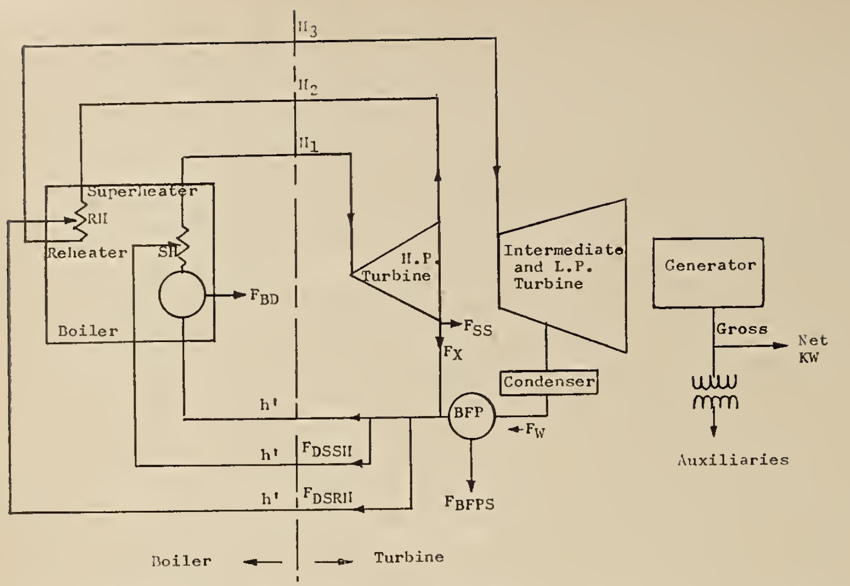


Fig. 3. Thermal Quantities for Turbine Generator Net Heat Rate Calculations

with the raw materials for heat calculation. Flow is conveniently measured at the input to the boiler feed pump where pressure and temperature conditions are most suitable.

Having measured net heat input to the turbine generator, its heat rate is established by comparing this with gross or net kwh. output. Overall heat rate is then computed by dividing the net turbine generator heat rate by boiler efficiency calculated as described previously. The value of these performance calculations can be increased by having the computer estimate "bogey" heat rate for the plant loading and operating conditions during the period reviewed. If required, an alarm can be provided when the difference between bogey and actual performance exceeds a predetermined limit.

Fig. 4 shows the method of checking performance of a component such as a feedwater heater. The input-output difference in feed and extraction flows is compared against normal conditions for the flow or load conditions at the time. Thus any deterioration in the component is rapidly shown up before it seriously affects plant performance.

We have to this point reviewed the application of computer techniques to automate the first three of the manual items listed earlier for conventional stations. In addition to the advantages listed for automatic data logging, the further benefits from using a computer for performance calculation are:

1) Performance results available more quickly — in seconds instead of days or weeks;
2) More flexible alarm structure as a function of loading or other process variable;
3) Higher scanning speeds and rate of scanning adjusted to suit importance of quantity measured;
4) Performance variation alarms available.

Computer Control

With the facilities previously described the operator's manual tasks would reduce to —

1) Taking corrective action when alarms from computer or other source indicated an abnormality;
2) Adjusting unit loading to suit system conditions;
3) Controlling the sequence of start-up and shut-down procedures.

Since the computer already has most of the *information* from the process it would seem logical to add to the computer the necessary *instructions* to carry out these routines. This is currently being done. Computer requirements in terms of memory capacity are considerably increased since more instructions must be provided and more information from the process collected and stored. The computer will be required to scan many contact inputs and some additional analog quantities to determine the state or position of auxiliary components. Routines which are provided include:

1) Start-up from cold;
2) Hot start-up (following short duration shut-down);
3) Normal shut-down;
4) Emergency shut-down;
5) Incremental loading;
6) System diagnostic and corrective action.

Fig. 5 shows in block diagram form the layout of a control computer for a thermal generating unit. It will be seen that analog quantities and contact positions are scanned to provide input information for control, performance calculation and logging. Output consists of contact closures for direct control and analog outputs where control is achieved by varying the set point of analog sub-loops. In addition, print-out of logged readings, alarm indication and performance results is supplied on typewriter, printers, paper tape or annunciator as required.

Fig. 6 shows a short portion of one of the many sections of a start-up routine to illustrate the type of checking and decision making which a computer is programmed to make. The logic of diagnostic and corrective action routine shows how a computer can handle minor or major emergencies arising under normal steady loading conditions.

The flexibility inherent in a stored program control computer allows maximum use to be made of the speed of a computer in decision making as well as in actual calculation. Complex start-up and shut-down routines which must in any case be setup for guidance of operators are stored in the computer memory and carried out step by step. Each operation is checked for satisfactory completion before a subsequent operation is initiated. Where close checking of some quantity is required during a phase of the start-up cycle, rapid scanning of the analog output from the appropriate sensor is initiated to give maximum supervision with alarm facilities during critical periods.

The program required for each portion of station operation is controlled by an executive program which selects the appropriate subroutine for control, scanning, logging or performance calculation. Since, while the speed of the computer may give the impression of doing many jobs simultaneously, it is in fact a sequential device, the executive program acts to give priority to more important functions if any possibility of conflict exists. Equally, the executive program by-passes any portion of scanning or checking which is not required for a particular operating condition.

A computer actuated control offers, in addition to the advantages listed for automated data logging and performance calculation, a reliable, unemotional control which will carry through preprogrammed sequences of operation with all necessary checks at each stage. Even under conditions of emergency when an operator may be distracted, the computer will not depart from the correct program. The ability of the computer to scan and compute the most essential quantities at each stage of a change in the state of the unit enables the timing of start-up and shut-down sequences to be linked more closely to equipment stress limits and the optimum times can be achieved without endangering equipment.

The Computer and Conventional Controls

It has been shown that computers applied for data handling and control of a thermal station will take over some or all of the manual processes which remain. We will eonsider now the relationship of the computer to existing controls. Both digital and analog controllers rely on the same types of sensors to measure the quantities upon which any control must be based. In general sensors are available to cover adequately the requirements. The trend to electrical controllers and away from pneumatic control has already produced sensors with electrical outputs which are suited to computer input. Typical of these sensors are:

Pressure: Strain bridges, transducers;
Temperature: Thermocouples, resistance thermometers;
Flows: Orifices plus differential pressure transducers.

Other areas where sensors are available but additional work is needed include flame detection, chemical measurement, specific gravity measurement, slag detection. These do not in general impose any serious obstacle to automating steam plants.

Having suitable sensing equipment there remains the choice of control by analog or by digital methods. At the moment the choice is to retain the present, well-tried analog controllers for the functions for which they have been used sueh as control of combustion, feedwater, temperature and for voltage regulation. These tasks are well suited to the analog controller since they involve two or three analog inputs and require an analog output to the actuator. For other tasks which have been mentioned, the digital approach is generally superior. The effectiveness of the analog controllers noted above may be increased in some cases by set point adjustment provided as output from the digital controller. This is used for example during start-up when boiler load is below the range of the analog controller. Analog devices which have been used for recording purposes may in many cases be replaced by digital display or recording of the quantity. Some analog records will be retained when trend information is important. Generally economics will play a key part in the choice between analog and digital methods and the analog approach is more suited for those portions of control which require continuous supervision. Where time sharing is possible between functions, when complex calculation is necessary or when complex sequences are to be carried out, a digital controller is indicated.

Why Automate?

So far we have described and illustrated the method of automatic control as applied to a thermal generating unit. Let us now review why such equipment should be considered. We have reviewed the improvements in operating characteristics achieved in each stage of progressive automation comprizing these categories:

1) Data Logging and Alarm;
2) Performance Calculation;
3) Automatic Control.

While these performance improvements may be satisfying aesthetically this will rarely be enough to justify additional expenditure to management. When we review the economic gains which may result, the subject can be properly appraised. The gains from complete automation are listed below.

1) Reduction in fuel costs: continous monitoring of performance and precise control can improve plant efficiency.

2) Improved continuity of service: constant scanning and prompt corrective action in emergency will reduce the number of unit outages.

3) Increased safety to personnel and equipment: continuous supervision will reduce the possibility of a major accident. Higher costs, larger size and more critical pressure and temperature conditions have increased the economic penalty of an operating error.

At the present time the items noted above have been the main justification for automation. A number of others can be listed and some of these may with further experience prove to be a major justification for equipment installation. These are:

1) Reduced operating costs: through more efficient use of manpower;

2) Reduced maintenance cost: through reduced equipment stresses;

3) Reduced auxiliary power: auxiliaries brought into use only when load conditions demand;

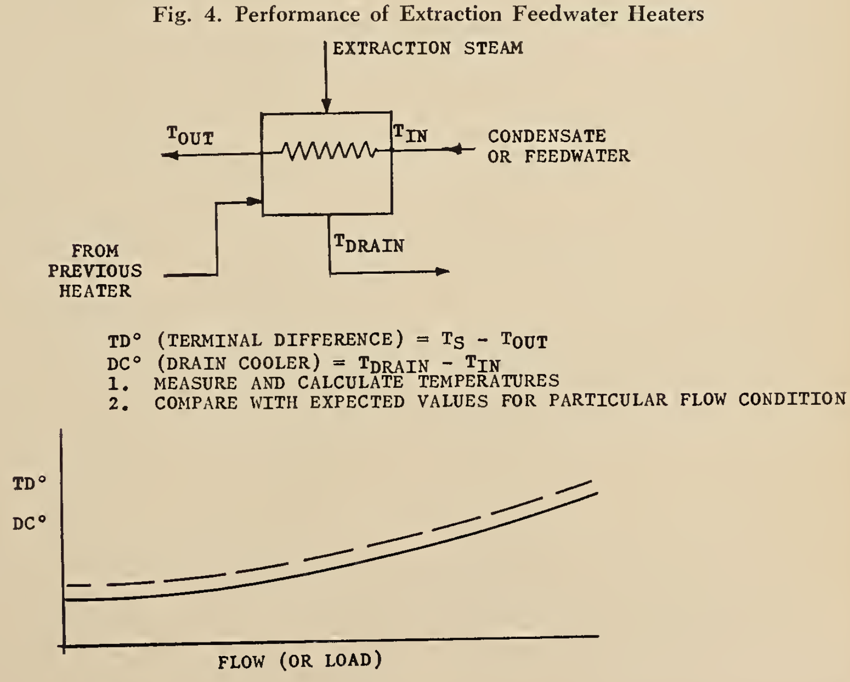
4) Reduced expenditure on control room and conventional instrumentation;

5) Removal of the need for periodic boiler and turbine tests: up-to-date performance values aid accurate load dispatching on incremental cost basis.

Some of these gains may be achieved at least in part by investing in less than complete automation. Where data logging and alarm alone is required, the equipment will not require the calculating or memory features of a computer. It may also be uneconomic to expand later and retain appreciable amounts of apparatus. On the other hand equipment to provide performance calculation does require memory and arithmetic features and may be quite practical to expand to complete automation.

The possible savings in some of these items are remarkably large when capitalized. For example with fuel costs of 30¢ per million B.t.u., capitalized savings from a ½% improvement in heat rate in a 2-unit

Fig. 4. Performance of Extraction Feedwater Heaters



average size plant may run to $150,000. As average unit sizes increase, such savings will grow.

Equipment Characteristics & Reliability

We have already noted that the reliability requirements for computers used for process control are much higher than for business or scientific calculation purposes. Three requirements must be met for satisfactory use in a control scheme.

1) Equipment must be designed to reduce component failure to an absolute minimum.
2) Failures must be detected rapidly and prevented from affecting the safe operation of the process.
3) Repair of the equipment must be made in the shortest possible time.

To meet requirement 1) the availability of transistors has been a major factor in permitting equipments to be constructed from almost entirely static components. This in itself is no magic guarantee of reliability but, combined with conservative application practices in which the transistors, diodes, resistors, capacitors, transformers and so on are used at a fraction of their normal ratings, a high order of freedom from failure can be obtained. These ratings range from one-tenth to one-half of normal depending on the device.

Another factor noted in reliability was rapid detection of failure. This is catered for in digital equipment by frequent self-checking routines called for by the executive program. When the self-check reveals an error the computer can set its output information to values safe for the process and commence to perform diagnostic routines which will inform the operator of the location of the fault. This facility is supplemented by the wide use of plug-in cards and other components so that faulted elements may be rapidly replaced from spare stock. To ensure that plug-in connections do not create more unreliability than they seek to cure, close attention must be paid to the design of the plug connection itself.

Scanning of input points is achieved by mechanical means using high reliability mercury wetted contact relays which are suited to the low level signal inputs encountered in industrial applications. By using a relay matrix, a high degree of flexibility in the sequence of input selection is achieved when compared with a sequential scanning device. At the same time equipment common to a large number of scanned points is avoided.

Memory requirements for an industrial computer can be provided in a number of ways but magnetic drum storage offers a number of advantages. The memory consists of a drum rotating at high speeds with information written on magnetized spots on the drum surface in much the same way as a tape recording. A number of recording heads spaced at the periphery of the drum provide writing and reading facilities. A magnetic drum offers large storage capacity at reasonable cost and is less sensitive to disturbance from power failure or system transients than some other types of memory. It does have a disadvantage that access to a particular piece of information may take time since one might have to wait until the drum rotates to the point that the information lies under a reading head. With a typical drum speed this could average 6-10 milliseconds but by careful programming, these access times can be reduced to much smaller values. The drum has far fewer components than other types of memory with equivalent capacity and is thus theoretically more reliable and easier to maintain.

Other Applications for Automation

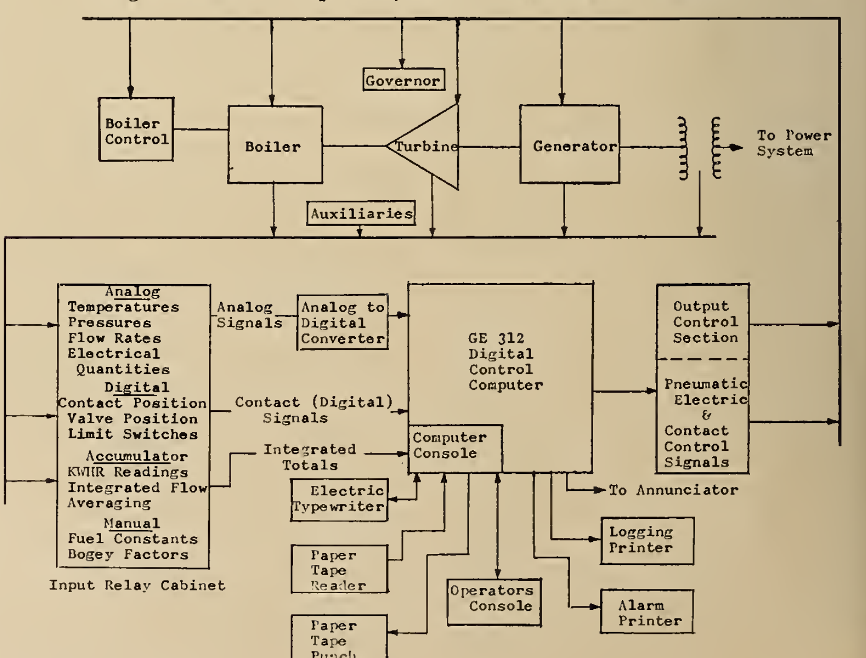
To place the automation of steam stations through the use of digital equipment in proper perspective, it may be useful to remark briefly on other industrial applications of automation. Steel production has in common with electric power generation the need for continuously reliable equipment to ensure high availability and maximum output from high capital investment. In steel also is a need for consistent high quality and uniformity in the end product. Thus it is not surprising that this industry has also been in the forefront in applying the facilities of high speed digital equipment for data collection, recording and control.

The data accumulation is used on a tinning line to measure and record defects on the strip. These defects are detected by a variety of sensors to show pinholes, off gauge sheet, and coating thickness. Coil identification is inserted manually.

Some special problems in memory arise since defects must be recorded in relation to the exact foot of strip in which they occur to permit totalizing prime strip footage free of defects. Results are recorded for each finished coil giving a record of quality which could not be produced by any other means.

Another example shows a fine match between analog control and digital control. Each stand of the hot strip mill has its own analog gauge control scheme. The computer is designed to optimize analog settings to produce the best load division between stands for optimum quality. It does this by estimating from incoming strip temperature the appropriate setting. This is a coarse calculation. It is based on assumed strip temperature from a surface temperature measurement and estimated hardness of incoming steel. By measuring actual power input to the first stand and comparing this with the computer's estimate, any deviations in temperature and hardness as they affect rolling quality are evaluated. These variations are used to repeat the calculations for the remaining stands in time to adjust the analog set-points of the

Fig. 5. Control Computer System for Steam Plant Automation



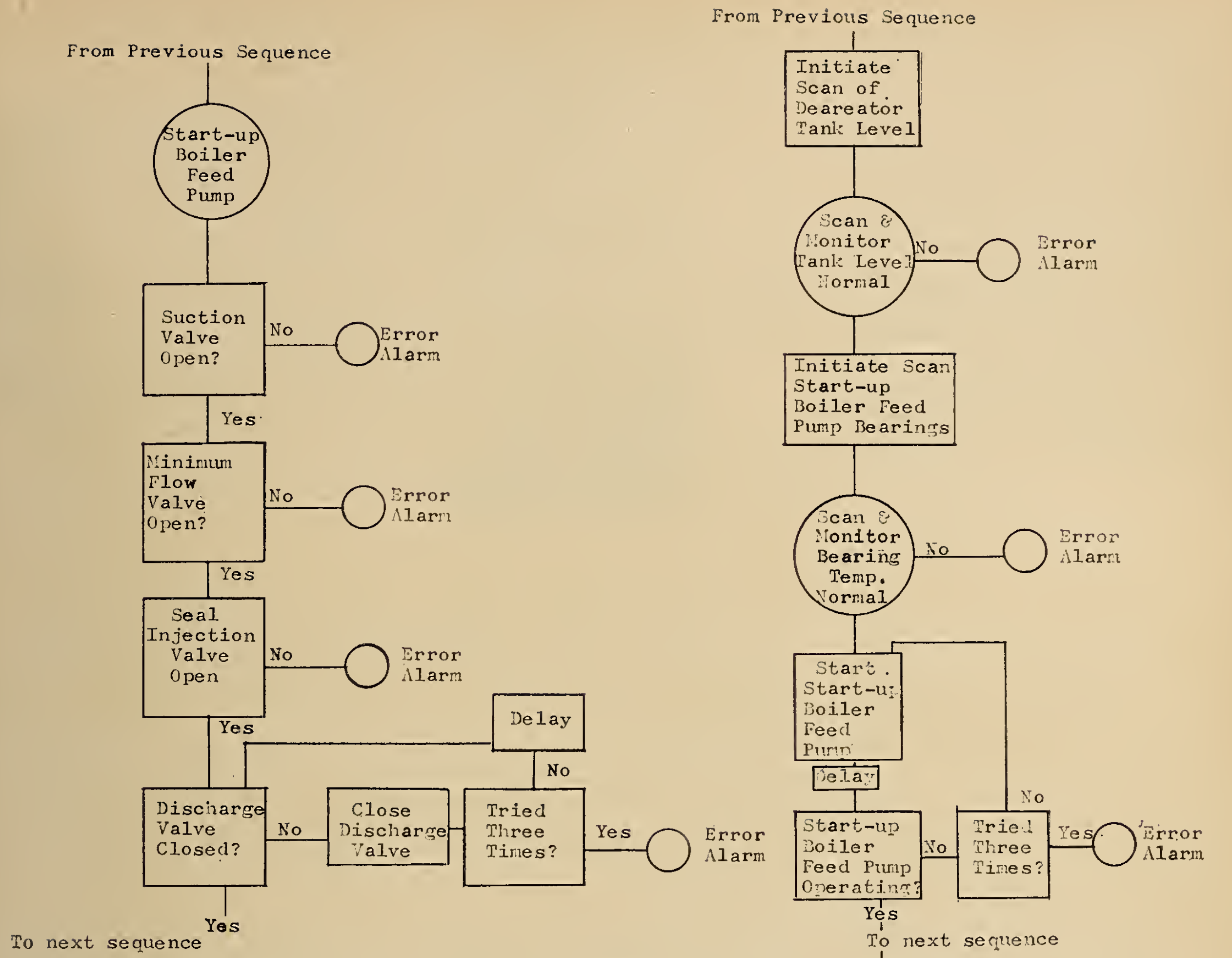


Fig. 6. Portions of Computer Orientated Start-up Sequence: Boiler Feed Pump

gauge controls even closer to ideal values. This is a good example of computer optimizing and "self education" in which it improves on its own best guess.

These necessarily brief remarks on two other industrial process applications serve to indicate how experience in many fields is being obtained and this all helps to ensure the best equipment quality and application techniques.

Conclusion

Steam station automation is but one example of the application of techniques and equipment which are producing an industrial revolution as significant as the introduction of steam power.

New apparatus does not change the basis of process control but merely expands the horizons of what can be achieved. Proper choice and good application depend on a review of the broad economic benefits which can be obtained. Justification may hinge upon lower costs of production, higher utilization of the investment in plant and better quality of output.

Computers permit higher speeds of calculation, more rapid corrective action and in many cases closer control. Computers require reliable apparatus, expert programming and full understanding of the process to be controlled.

A computer can help solve some of its own problems by collecting data and providing performance results from processes which are insufficiently understood. Further, by programming on an optimizing basis, a computer can improve upon the initial results much as a human being gains skill as he becomes more familiar with his job.

Best results will follow if the computer is designed into the process rather than by being superimposed upon it. A clear philosophy of application should be allowed to permeate the programming of the computer, the application of conventional control and the provision of conventional instrumentation. In general the operator should be presented only with information upon which he is required to make decisions. Data of historical value should be recorded separately. Where computed results give significant indication of process conditions, the raw data used in the calculation need not be preserved.

While automatic control of a thermal generating unit may require the scanning of 300 to 600 analog quantities and up to 600 contact inputs, the historical record may contain only 10 to 50 items. Thus what may seem to have started out as the compounding of complication upon an already complex process has resulted in opportunity for improved performance and at the same time reduces significantly the information which the plant operator must review to provide effective supervision.

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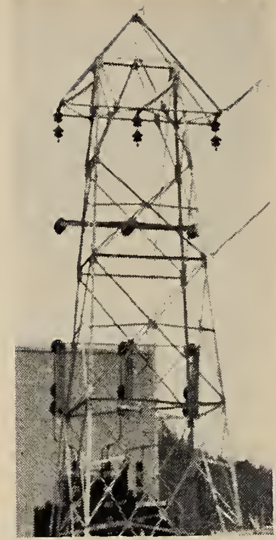

STANDARD ALUMINUM SUBSTATION STRUCTURES

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A substation in popular use by electrical utilities in Ontario[1] is the outdoor open construction with the high and low voltage lines overhead. This type of substation is used in areas with low load densities such as rural or suburban localities. It has a simple layout with lightning arrestors, an air-break switch and fuses on the supply line to the high voltage side of the transformer, and fuses on the low voltage feeders. The design provides for oil circuit breakers and load interrupter switches which are commonly used in addition to the low voltage fuses. Separate structures for the high voltage and low voltage equipment give a maximum of flexibility in the layout. The transformer bank, one 3 phase or three single phase units, is located between the two structures. The station is used with supply voltages up to 44 kv. and up to 12 kv. on the feeders.

THE DESIGN of the low voltage side of this station is very flexible. The secondary switches, fusing, metering, voltage regulation and number of feeder circuits can be varied to suit the load requirements. The overhead feeders can be taken off in several directions without extreme changes in the secondary structure. Where the right of way for overhead lines is restricted, the high voltage line can enter from the street and the secondary lines can leave the station in the same direction. They may even be mounted on the same pole. With such a versatile station design, the structures must be designed to accommodate a great variation in equipment.

The demand for this type of station increased with the steady load growth in the rural and suburban areas. The versatility of the station design presents the manufacturer with the problem of producing a standard structure to meet the exact requirements of the purchaser.

Bolted Steel Structures

An early design consisted of an H-frame structure for the high voltage equipment and a four column box structure for the low voltage equipment with all members made from single channels and angles of galvanized steel. The individual pieces were cut and holes were punched before galvanizing. In a bolted structure of this type all connections are made in the field. The weight of the steel for the high voltage structure is 2,500 lb. and for the low voltage structure is 3,000 lb.

There are several disadvantages to the bolted steel structure. Each non-identical piece of the structure requires a detail drawing before it can be manufactured. The length of members is limited by the available galvanizing facilities. Galvanizing tends to block holes making extra work for the erectors. The need for enough material around bolt holes limits the minimum size of members. The main disadvantage of this type of construction is the large number of bolted connections that must be made during the field erection.

Welded Steel Structures

To reduce the number of field connections, a welded type of structure was developed. Columns and girders, consisting of four chord angles with lacing of rods and light angle, are shop-welded. By restricting the overall dimension to a few common sizes, standard methods can be used for manufacturing the structural members. Dimensional tolerances can be maintained. Component parts can be kept in stock. Engineering time is reduced.

The use of shop-welded columns and girders is ideal for the standard substation structure. The basic design work is done in advance of an order. The designer selects the correct size of members from stock and adds only the extra parts necessary to adapt the standard structure to the special requirements of the station. As we have seen above, many variations of equipment are mounted on the low voltage structure. It is here that the designer may, of necessity, deviate from standard members.

The field erection is simplified, because of the fewer number of pieces. The parts are easier to identify and locate in the structure.

A typical example of this type of station is shown in Fig. 1. It was erected in July, 1958. This station has a 13.8 kv. high voltage line entering the primary structure at a height of 31 ft. above grade. The high voltage equipment mounted on the structure consists of: 3 pole gang operated switch, 3 lightning arrestors, 3 power fuses and bus supports. The 3000 kva., 3 phase transformer is located between the high voltage structure and the 4.16 kv. secondary structure. Two, four-wire, feeder circuits are strained off the secondary structure in two directions with provision for adding a third circuit. The low voltage equipment consists of load interrupter switches and fuses on each feeder circuit.

The primary H-frame structure is made from only 7 shop-welded assemblies and weighs 2,500 lb. The secondary structure weighs 4,100 lb.

Standard welded columns used in the station are 12 in. x 12 in. and 12 in. x 30 in.

The use of steel, in the welded assemblies, presented a number of difficulties. The length of the members was still limited by the galvanizing facilities. The maximum length of a 12 in. x 30 in. column that could be galvanized was 20 ft. The weight and bulk of the welded member prevented the shaking of excess galvanizing from it, so that build-up was common in holes and sharp tips were left to cut the hands and belts of the erection crew. Twisting and bending, resulting from the heat of the galvanizing process, made it necessary to straighten the welded assembly before it could be erected.

This substation design, using prefabricated steel members, was accepted by users as being a great improvement. Many industrial and utility stations of this type were erected and are still in service throughout Ontario.

Why Aluminum

Investigations, however, continued in an attempt to reduce the difficulties encountered in galvanized steel substation structures. These led to the examination of aluminum as an alternative to steel.

Aluminum as a structural material has many features to recommend its use in outdoor substations. One of its salient properties is resistance to most atmospheric environments. Because of the natural affinity of aluminum for oxygen, an oxide film is always present on the surface of the metal. This thin, dense film is tenacious and self-healing and provides the key to aluminum's ability to resist attack by various corrosive agents.

The structural aluminum alloys are practically impervious to sulphur-contaminated industrial atmospheres as well as salt-laden coastal air, or even a combination of both. Tests by the Alcoa Research Laboratories[2] indicate that ⅛ in. and 3/16 in. material after 20 yr. exposure to a severe industrial atmosphere (at New Kensington, Pa.) would suffer a loss of tensile strength of approximately 1.5% and 1% respectively. In a coastal atmosphere (Pt. Judith, R.I.), the loss would be even less. The good corrosion resistance of aluminum is a significant factor in reducing maintenance and enhancing appearance.

Structural aluminum alloys perform satisfactorily adjacent to such alkaline materials as concrete.[3,4] Likewise, no detrimental effect results from contact with hot dipped galvanized items encountered in substations such as insulator pins, caps, switch bases, line hardware, splice or anchor bolts.

The aluminum alloys normally specified for structural use, compared with steel, have ultimate tensile strengths ranging from 63% to 100%. However, the tensile yield strengths vary from 66% to 140% of the yield strength of steel. All aluminum alloys exhibit a narrower spread between the ultimate tensile and yield strengths than does structural steel. That is to say, the yield strength of a structural aluminum alloy is a greater percentage of ultimate strength than is the case with structural steel.

The coefficient of linear expansion is approximately twice that of steel while the modulus of elasticity is three times. The result is that stresses, due to temperature changes, are less in aluminum than in steel. Because of the lower modulus of elasticity, deflections in aluminum are approximately three times that of steel under identical conditions.

Aluminum can be readily extruded using relatively inexpensive dies. This means that special shapes, which make the most efficient use of the material for any particular design, are both practical and economical. To take advantage of maximum economies it is, however, necessary to purchase in large quantities. The lengths of members are limited only by handling and transportation considerations, rather than by the length of galvanizing tanks as is often the case with galvanized steel members.

Frequently, it is necessary, or desirable, to make alterations at the site. These may result from design changes or additions to the station. Aluminum can be drilled without difficulty and without impairing its corrosion protection.

Bolted Aluminum Structures

The first attempts, at the utilization of aluminum in substations, involved standard structural shapes. It has been common practice for designers to substitute aluminum for steel structural shapes, increasing the size of the aluminum members to obtain comparable rigidity. These structures were either bolted or rivetted and were almost exact copies of their steel counterparts. This design method did not result in the most economical aluminum structures. The weight of the

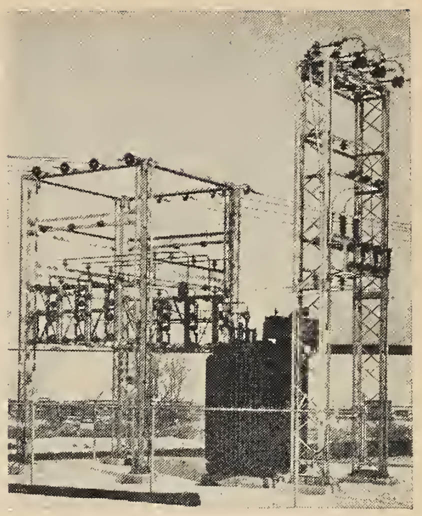


Fig. 1. Prefabricated galvanized steel structure 13.8 kv. primary, 4.16 kv. secondary

aluminum structures ranged between 50% and 75% of steel and the cost was two to three times. The designer was restricted to the limited number of sizes and shapes available from warehouse stock, unless he was prepared to purchase in mill quantities. The higher price of warehouse material, together with the limitations in sizes, had a considerable influence upon the cost of the structure. Aluminum substations, therefore, could only be justified economically where the initial cost was of secondary importance. Examples of this are coastal regions and locations with an atmosphere heavily contaminated with salt, ammonia or sulphides, where the cost of maintenance of steel stations is excessive.

Welded Aluminum Structures

Aluminum can be arc welded using either one of two conventional methods. Both methods rely upon the use of an inert gas envelope about the arc to prevent oxidation of the molten metal. These are known in the trade as MIG and TIG. The Metallic Inert Gas method uses a consumable aluminum alloy electrode while the Tungsten Inert Gas method employs a non-consumable tungsten electrode. Welders must be specially trained. Cleanliness of the joints is even more important than with steel. A very rigid routine of quality control is necessary to assure high quality welds.

After assessing all the pertinent technical factors, together with fabrication and erection costs, it appeared that a welded construction, similar to the prefabricated steel members previously produced, would be the most economic.

First attempts, at welding substation structures, were far from being competitive, in price, with steel. When using conventional shapes for chord angles and rods for lacing, it was necessary to weld both inside and outside the box member to obtain a good connection. In the welding of tempered alloys, there is a tendency to anneal the metal adjacent to the weld zone, thus preventing the maximum utilization of the physical properties of the alloy. This is due to the precipitation of the alloying elements from the solid solution.[5] The extent of the zone is dependent on the welding speed and other factors which are discussed later in this paper.

The Unique Bulb

It was found in welded test trusses that failure occurred in the chord angle, starting from the edge of the chord angle and progressing inward. The attempts to solve both these problems led to a very interesting and important development.

A bulb was placed at the edge, or toe, of the angle. The legs of the angle were reduced to avoid an increase in the weight. The strength of the chord angle was thus increased without increasing the weight. A notch was placed in this bulb, making possible a combination fillet and butt weld with the lacing. In this arrangement, the weld metal flows down the end and up the side of the lace, producing a strong weld without the need for welding inside.

The most important function of the bulb is the reduction of the heat-affected area. Most experienced welders are familiar with the technique of using a copper back-up plate to rapidly remove the heat from the weld zone to minimize the annealing of the welded metals. The bulb serves a similar purpose so effectively that the chord angle is stronger at the weld than between welds. This means that the slight increase in the moment of inertia of the angle, due to the addition of the weld metal and the small amount of lacing, more than offsets the softening effect on the metal adjacent to the weld zone.

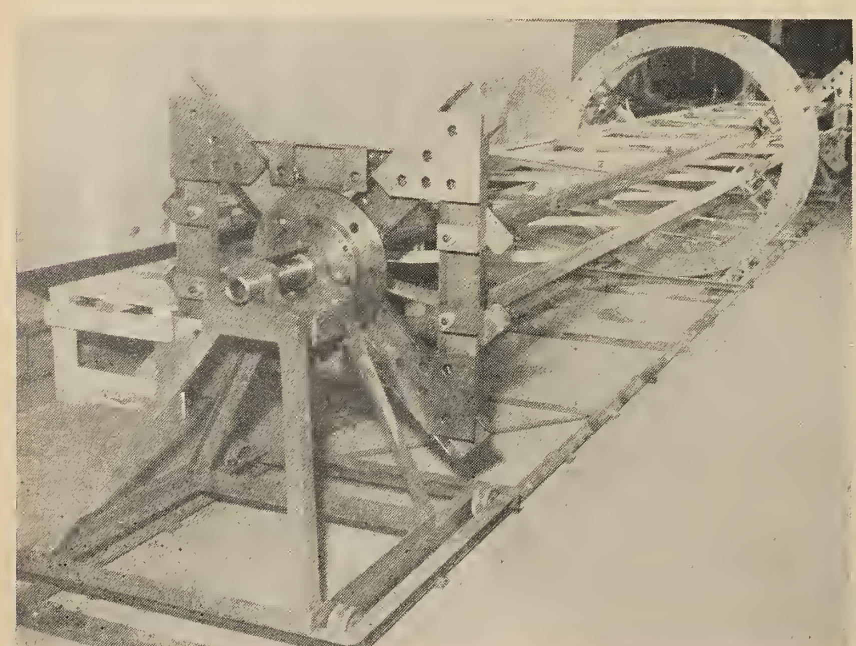
The notch in the bulb performs still another service. By forming a track, when the chord angles are set up for welding, the lacing can be quickly and easily located and held in place until welded.

With welding of substation structures thus becoming economically feasible, coupled with sections designed specifically for welding in order to develop the maximum benefit from the metal, the advantages of shop fabrication accrued.

Production Methods

The next step was to install specialized shop equipment and to develop production fabricating techniques. The extrusions are normally purchased in 30 ft. lengths and must be cut to length for manufacture. Several cutting methods were investigated. A fast, clean cut was desirable; safety and accuracy were important. The solution was in a high speed, carbide-tipped, circular saw. The saw is the type which moves transversely while the work remains stationary. Water is used as a coolant to avoid the necessity for any cleaning of the cut edge prior to welding.

Fig. 2. Partially fabricated column in the special welding fixture



A special welding fixture was designed to accommodate columns up to 36 ft. long. A fixture (Fig 2) consists essentially of 2 large faceplates, fitted with toggle clamps, so that each chord angle can be held securely with 2 clamps at either end. The location of the clamps is adjustable to cover the entire range of column sizes. The face plates are mounted on wheels set on an angle iron track. Their location can be adjusted to suit box members from 4 ft. to the longest.

The fixture is positioned so that the panels of the column are at 45° to the horizontal. Then, the lacing for one panel is laid in place in the tracks formed by the notches in the chord angles. The welder starts welding at one end and proceeds to the other, completing the panel. The face plates, supporting the work, are rotated 90° and locked in position while welding each subsequent panel. The purpose for the 45° angular position for welding is to reduce operator fatigue and to put both chord angles within easy reach of the welder.

To prevent distortion in the longer columns, a third element of the fixture is used. This comprises a ring large enough to surround the largest column. It is fitted with 4 wheels with their faces machined to a 90° vee. These wheels are adjusted to contact the chord angles to prevent their movement. This ring is likewise mounted on wheels and is moved along the track ahead of the welder. With this equipment, it is possible to construct a 30 ft. girder with a maximum deformation due to welding of ⅛ in.

The MIG welding process was selected in preference to the TIG method for several reasons. MIG uses direct current with high current densities, permitting high welding speeds because the current in the consumable electrode is not limited by the melting temperature of the electrode as in the TIG process. A high welding speed means more rapid cooling with less distortion and less annealing in the weld zone. High current densities, together with the efficient heat transfer in the arc, make good penetration possible. The process is ideal for position welding and the automatic feed of the electrode is less fatiguing to the operator and less time consuming than the stick electrode used in the TIG process. The net result of these factors is increased mechanical properties, better corrosion resistance and lower labour costs.

Production welds are carefully inspected for cracks and flaws and samples are tested regularly to assure weld quality. Test specimens are welded under the same conditions as production assemblies. The specimen is cut transversely to the weld and etched to show the weld penetration. Tension tests are also performed to ensure that the weld strength conforms to design requirements.

A 3/64 in. diam. electrode of 56S aluminum alloy is fed into the arc at a rate of 450 in. per min. The arc travel speed is approximately 12 in. per min. Since an Argon gas shield is used to prevent oxidation rather than a flux as with steel, extensive cleaning of the weld is unnecessary. After welding, a light wire brushing is performed, however, to facilitate weld inspection.

Advantages of Welded Aluminum Structures

It is obvious, from the foregoing, that the key to the economic utilization of aluminum in substation structures is its extrudability and weldability. As a result, entire columns and beams can be fabricated in the shop in a fraction of the time required to assemble a bolted structure on the site. Shop fabrication can be performed under more suitable conditions, using specialized equipment and skilled labour more efficiently. Work in the field frequently involves living accommodation for the construction crew. With the reduction in field labour, this expense is likewise reduced.

The light weight of aluminum is reflected in many places. The handling of chord angles in the shop requires only one man; a comparable steel angle would require two men or a crane. Transportation costs and the structure foundation costs are reduced. Smaller crane capacity is possible. Some small stations have been erected by hand. With the reduced weight of the girders, it is frequently possible to attach such items as; switches, 'bus supports, fuses, etc. on the ground and hoist them into place along with the girders. The men can guide and handle the lighter beams more easily during erection.

Since the structural members have not been subjected to the heat of galvanizing pots, they are straight and true. Mating parts are easily aligned. Sharp points are eliminated. The faces of the columns are smooth which simplifies the fitting of components and makes climbing easy.

Aluminum's excellent corrosion resistance gives a better appearance and reduces maintenance and power interruptions for painting. In very aggressive atmospheres, galvanized steel stations may require painting as often as every five years.

With the present price differential of the two metals, the first cost may favour the steel structure. However, with the savings in transportation and erection, the installed cost frequently is in favour of aluminum.

Standard Design

The development of standards was the next logical step in the evolution of this system. Standardization was necessary for many reasons. Since each extruded shape requires its own die and the extrusions must be purchased in 25 ton quantities to obtain the lowest price, it was desirable to keep the number of shapes to a minimum. The present range of columns and girders can be fabricated from a total of 5 shapes, 3 chord angles and 2 tee lacings.

Similarly, the sizes of columns and girders have been standardized. The sizes shown in the table below have been found to satisfy most requirements both structurally and economically.

DEPTH (Inches)	WIDTH (Inches)			
	12	24	30	36
12	x			
24	x	x		
30	x	x	x	
36	x	x	x	x
48	x	x	x	x

The application of these shop-fabricated aluminum members to the standard substation is shown in Fig. 3. This is a 23 kv. 3,000 kva. station with a secondary of 4160 v. It was laid out for 3 secondary feeders ultimately, with 2 connected at present.

The primary structure is essentially a duplicate of the high voltage section of the steel station (Fig. 1) which was previously described. It consists of 12 in. x 36 in. columns, 29 ft. high, with 12 in. x 36 in. girders. It is designed for line pulls of 1000 lb. each. The aluminum weight is 1030 lb., which is 41% of the weight of the similar steel structure.

In the secondary structure, the feeders all leave the station in the same direction so that the weight of aluminum cannot be directly compared with that of the secondary steel structure in Fig. 1. Four 12 in. x 12 in. columns, 20 ft. high, with 12 in. x 24 in. girders and some 12 in. trusses are used in the secondary structure. The aluminum weighs 2600 lb.

If this structure were scaled down to the size of the steel structure (Fig. 1), the weight of aluminum would be 1640 lb. or 40% of the steel design.

By careful co-ordination of the design of the various substation arrangements and voltage classes, standard lengths of columns and girders have evolved. The advantages of standardization have been achieved without losing the flexibility necessary to accommodate special designs.

The reduction in engineering time for standard substations is immense. There is also a considerable saving in designing a special station. Tables of the properties of the various box member sizes assist the designer in quickly selecting the column or girder for his needs. Standard drawings reduce the drafting time to a few hours for standard station arrangements. The draftsman, by using pre-printed detail drawings of columns and girders, has only to add the overall dimensions and locate the holes.

When designing standard aluminum substation structures, careful consideration must be given to; the properties of the aluminum alloy, the deflection of members and the method of splicing and joining sections.

Design Data

The aluminum alloy used in the extruded chord angles and tee lacings is a heat treated alloy with a minimum guaranteed yield strength of 37,000 p.s.i. and a guaranteed ultimate strength of 42,000 p.s.i.[6] The high strength of this alloy allows a working tensile stress of 17,500 p.s.i. to be used in the design of the aluminum structures. This represents a factor of safety of 2.12 based on the minimum guaranteed yield strength. The factor of safety, with respect to yield strength, is larger than ordinarily encountered in specifications for structural steel, because there is a smaller spread between the yield strength and the ultimate strength of aluminum.

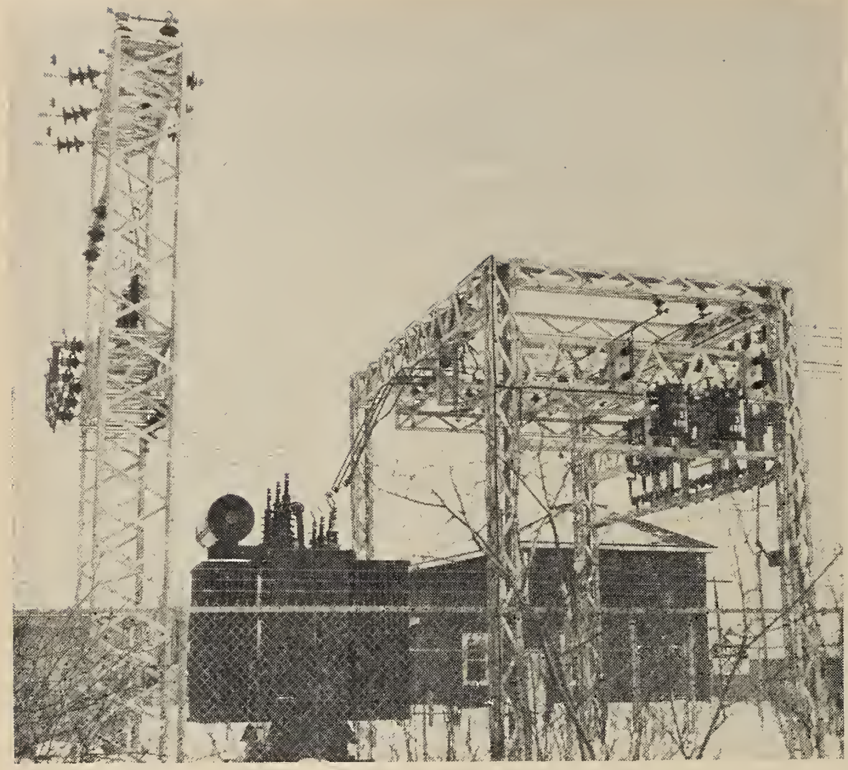


Fig. 3. Prefabricated aluminum structure 23 kv. primary, 4.16 kv. secondary

Deflection is limited to 1/300 of the span by the N.E.M.A. Standard for Power Switching Equipment No. SG6-8.02E, October 1956,[7] but this mainly concerns steel structures supporting air switches. This limitation is intended to prevent binding and difficult switch operation due to misalignment of the operating mechanism. Deflection on upright members can exceed this limit of 1/300 without affecting switch operating mechanisms and, in most cases, a deflection of 1/150 is allowed. Unless higher line tensions are specified, a line pull of 1,000 lb. per conductor is used.

Ice loads, for steel structures, are usually assumed as 100% of the weight of the structure. Because of the difference between the weight of steel and aluminum, the weight of the structure should be multiplied by a factor of 2.8 to calculate an equivalent ice loading.

Splices and connections are made from ⅜ in. thick plate of 65S-T6 aluminum alloy. Bolts, nuts and lock nuts used to assemble the aluminum structure are steel, aluminized to prevent corrosion. Steel bolts were chosen because of their higher shear strength and lower cost as compared with aluminum alloy bolts.

Aluminizing is a relatively new process whereby virtually pure aluminum is applied to steel parts by a hot-dip method. The aluminum is diffused into the steel, forming an interfacial layer which provides a tight metallurgical bond for the outer layer of pure aluminum. Atmospheric exposure tests of aluminized steel have been conducted in the United States over the past 30 yr. The results indicate that aluminized steel has at least three times the life of galvanized steel in industrial and rural atmospheres. Recent tests have also demonstrated the superior corrosion resistance of aluminum-coated steel in marine environments.[8]

The minimum diameter of bolts used in splices, gussets, braces and other structural connections is ⅝ in. The structural members are designed to use as few different lengths of bolts as possible. The nuts are washer faced to bear evenly on the aluminum sections. Split lock washers which might damage the aluminum are not used, but to ensure positive bolting action, concave lock nuts are assembled after the nut has been fully tightened. Aluminum bolts of 24S alloy can also be used but both the bolt and nut should be anodized or lubricated to prevent galling of the threads.

During the month of December, 1959, the James R. Kearney Corporation of Canada, Limited in conjunction with the Aluminium Laboratories Limited, conducted a series of strain tests on various sizes of welded columns to confirm design calculations. Nine different columns were tested and load-deflection readings were made. Final results are not available at the time of writing, but preliminary reports appear to substantiate the design calculations.

Based on the tests, additional design work is proceeding with the objective of reducing the material content still further, particularly in the smaller sizes of welded members.

Conclusion

Standard prefabricated substation structures offer the user many advantages: faster delivery, less field work, less engineering time and lower installed cost. The manufacturing and engineering costs are reduced by the use of standard components and designs.

The use of aluminum adds still more advantages to the standard substation: better corrosion resistance, improved appearance, reduced maintenance, lower erection costs, reduced weight and greater flexibility.

The development of this system has made the installed cost competitive with steel. It appears this trend will continue. Aluminum substations are gaining popularity throughout Canada.

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LONG RANGE HYDRO PLANNING FOR MANITOBA

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The Manitoba Hydro-Electric Board, Winnipeg.

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This paper outlines the growth of the Power Industry in Manitoba and the location of the Water Power Resources in and adjacent to Manitoba. It discusses factors which will bear on the development of these resources and the methods used in evaluating system growth. It presents a visionary picture of the full development of the Nelson River and redevelopment of the Winnipeg River and includes an Appendix on economic factors affecting system development with a request for an exchange of views on economic methods of project evaluation.

IT HAS become increasingly important for electrical utilities to plan for their system expansion in an orderly fashion. The complications of system interconnection, of system load growth, and variable costs, make it more important than ever that utilities select a sequence of development which will produce the most reliable power at the lowest possible cost to their consumers. A short review of Manitoba's position is presented for the benefit of those not familiar with the growth of Central Station power in Manitoba.

Growth In Manitoba

Back in 1906, the first Winnipeg River plant at Pinawa was constructed by the Winnipeg Electric Company. Up to that time, power had been supplied by a small number of thermal-generating units, located in the City of Winnipeg proper. The municipal authorities decided to enter the generation field with a municipally owned plant. Consequently the City of Winnipeg, having undertaken to develop the Pointe du Bois site, brought this plant into production in 1911. This was the start of the City of Winnipeg Hydro-Electric System. Subsequently, in 1923, the Winnipeg Electric Company developed Great Falls on the Winnipeg River installing the first high head propeller type units on the continent. In 1931, the Seven Sisters site was developed by a subsidiary of the Winnipeg Electric Company, and the Slave Falls site was developed by the City of Winnipeg Hydro-Electric System. These partial installations gave the area sufficient capacity to meet requirements until the end of the war, and then both utilities were without sufficient capacity to meet all conditions of river flow and corresponding load requirements. Consequently, both Winnipeg Electric Company and City Hydro commenced a programme of extension to the Seven Sisters and Slave Falls sites respectively, and by 1952 and 1949, both of these developments were completed to capacity by these two organizations. In 1931, the Winnipeg Electric Company contracted to generate all the power needs of The Manitoba Power Commission, which supplied at that time all the rural areas of Manitoba including the Western part of the Province.

In 1947, the Manitoba Government retained the services of Dr. T. H. Hogg to bring down a report[1] on the future policy of the Provincial Government regarding generation and transmission of power. In 1948, Dr. Hogg's report was tabled and the main recommendation was to the effect that all new generation should be undertaken by the Provincial Government.

As a result of this recommendation, the Government immediately initiated development of the Pine Falls site on the Winnipeg River which came into operation in 1951 and was tied into and operated by the Winnipeg Electric Company system.

In 1951, The Manitoba Hydro-Electric Board was formed and assumed the ownership of the Pine Falls plant which had been undertaken prior to the formation of the Board by the Department of Mines and Natural Resources, and it proceeded, upon completion of Pine Falls to develop McArthur Falls, which was the last remaining site on the Winnipeg River. The rapid growth of the energy demands in Manitoba and the farm electrification program pointed to additional sources of generation being made available as quickly as possible.

The development of the last Manitoba site on the Winnipeg River then required a move to thermal generation in order to keep generation in pace with the rapidly growing demand. There was also the problem of reorganization of the power industry based on Dr. Hogg's report. Following many months of negotiations and the purchase by the Provincial Government of the electrical assets of the Winnipeg Electric Company, the situation resolved itself into:

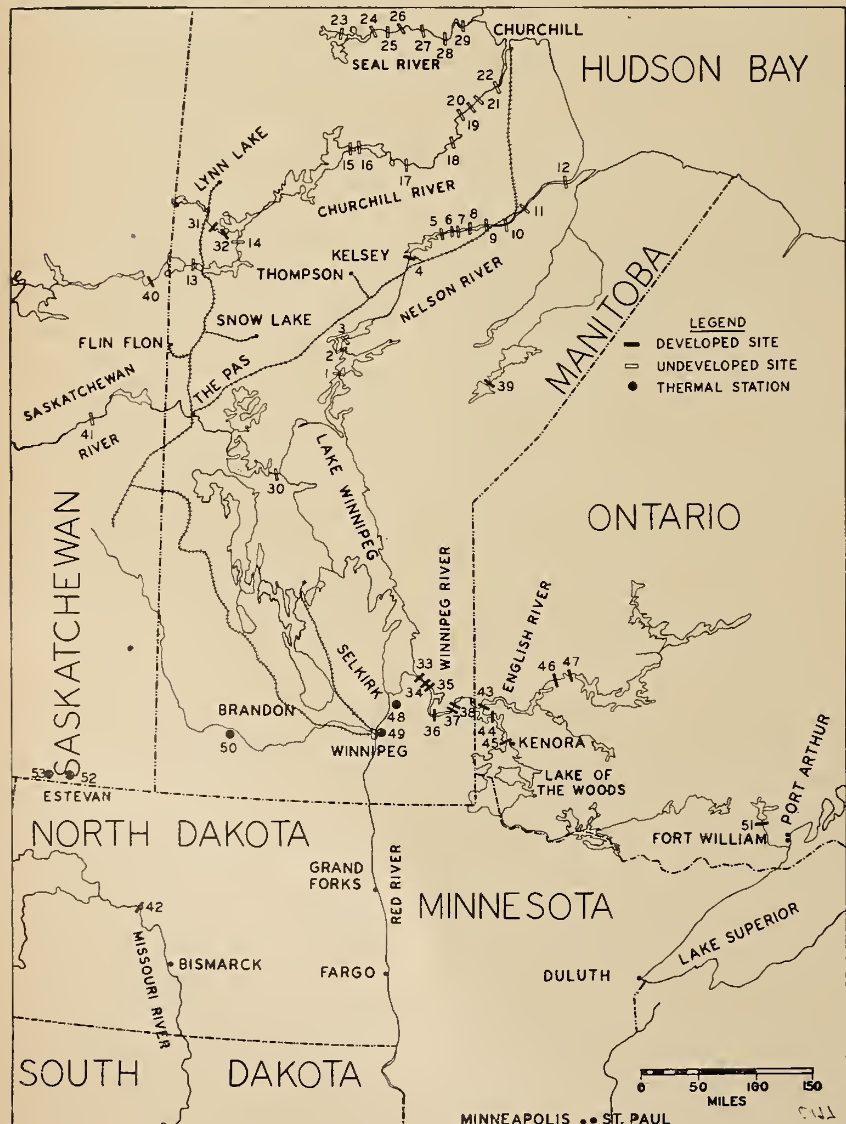
1. The Manitoba Hydro-Electric Board being the principal generation and transmission agency in the Province;
2. The Manitoba Power Commission being charged with the responsibility for distribution in all of the Province except the City of Winnipeg;
3. The City of Winnipeg Hydro-Electric System left with its own distribution within the city, the newly acquired distribution facilities of the Winnipeg Electric Company within the city and the retention of its own two hydro plants on the Winnipeg River, together with the thermal station at Amy St. in the City of Winnipeg proper.

Prior to this re-organization, the City Hydro and the Winnipeg Electric Company were operated as two separate generating systems. However, under the present re-organization both systems operate in parallel and are tied in at the 60 kv. level at both Mill St. and McPhillips St. both within the city boundaries. The accompanying Fig. 1 shows a map of the Province of Manitoba with the location of the major generating stations.

In addition to the outline above The Manitoba Hydro-Electric Board undertook to interconnect with the Northwestern region of the Ontario Hydro-Electric Power Commission in 1957, and have been operating an interconnection with Ontario since that time. In addition, The Manitoba Hydro-Electric Board and The Saskatchewan Power Corporation are constructing a 230 kv. line which will shortly be placed in service at 138 kv. between the Boundary Dam Thermal Generating Station near Estevan of The Saskatchewan Power Corporation and the Brandon Thermal Generating Station of The Manitoba Hydro-Electric Board.

To keep pace with the increasing power demand, The Manitoba Hydro-Electric Board constructed the Brandon Thermal Generating Station installing four 33 mw. units for a total capacity of 132 mw. in 1958. This plant feeds into the 115 kv. transmission system which belongs to The Manitoba Power Commission in its transmission pattern from Winnipeg West to Brandon. In addition, The Manitoba Hydro-Electric Board has constructed a second thermal-electric generating station at Selkirk, some 20 miles north of Winnipeg. The initial installed capacity is two 66 mw units, and these will both be commissioned during 1960. The interconnection with The Saskatchewan Power Corporation, which was briefly mentioned earlier, will operate initially at 138 kv., but a complete provision for future operation of 230 kv. has been built into this line. It is a wood-pole "spar-type construction" line, with a voltage regulating transformer with on load tap changing gear located at the Brandon Thermal Station.

Fig. 1 Map of Manitoba and Surrounding Area showing power developments, and potential developments.



In the northern part of Manitoba, The Manitoba Hydro-Electric Board has the Kelsey Generating Station, at present under construction, to supply a load to the International Nickel Company of Canada. This station is scheduled for commissioning of the first two of five 42,000 hp units in the summer of 1960. The Churchill River Power Company, which is a subsidiary of the Hudson Bay Mining and Smelting Company, owns and operates the Island Falls Generating Station on the Churchill River in Saskatchewan. This plant supplies loads in the Flin Flon area, and the requirements of the Hudson Bay Mining and Smelting Company, located in Manitoba, are met from this generation.

There are two other small electric developments in Northern Manitoba, one at Kanuchuan in the eastern part of the Province, and the second at Laurie River where two plants are developed to supply the Lynn Lake mining operation. Kanuchuan has a present installed capacity of 1900 hp with an ultimate of 5700 hp while the Laurie River site No. 1 has a present installed capacity of 7000 hp, which is its limit, and Laurie River No. 2 also has installed 7,000 hp.

This brief review of the developments in operation or shortly to be placed in operation in Manitoba, will serve as a background for discussion of the more complex problem of the development of the electrical system of Manitoba which follows.

Load Growth

Referring to Fig. 2, Firm Winter Peaks of Southern Manitoba System 1934-35 — 1959-60, it will be observed that from 1940-41 there has been a constant growth of approximately 7% represented by the dots. This trend in 1958-59 was re-established after a two year low from 1956-58, where increases were relatively very small. This return to the trend line was established by the peak of 617.1 mw that was experienced in January 1960.

The 7% load growth when compounded, amounts to a doubling of the electrical system approximately every ten years. The peak load for the Manitoba System in 1948 was 309.6 mw and in 1959 it was 614.1 mw. The energy requirements in 1948 were 1,581,000,000 kwh. and in 1959 they were 3,237,400,000 kwh.

In 1960, with the installation of the

two thermal units at Selkirk, the generation capability of the Southern System will be 850 mw made up as follows:

Winnipeg River	—Hydro-electric	560 mw
Amy Street	—Steam-electric	45 mw
Brandon	—Steam-electric	122 mw
Selkirk	—Steam-electric	123 mw
	Total	850 mw*

*With station service deducted.

When the Northern System capacity, now being installed at Kelsey, is added to this, the figure will exceed 1,010,000 kw. although the Northern and Southern Systems are not interconnected at present.

Assuming that we are going to continue these upward trends in power use, we shall reach a 2,000,000 kw. system by 1970 and a 4,000,000 kw. system by 1980 and perhaps a 16,000,000 kw. system by the year 2000. Now it is to provide for these possible rates of growth that we shall examine the future trends of Manitoba's power generation and major transmission requirements to satisfy loads of this magnitude. We must so maintain our position that we can meet this doubling every ten years should it happen that our expansion continues to assume a 7% or better rate of load growth.

Manitoba is favoured with large base metal resources and potential base metal industries. This is evidenced by the start in Northern Manitoba—at Lynn Lake, Thompson and so on—to bring some of these known resources into production. The map of Manitoba (Fig. 1) shows that most of the hydro-electric resources at our disposal are a considerable distance from the Southern load centres as we know them today. There is every indication that Manitoba may exceed the 7% load growth trend in the future.

System Planning

(a) *Water Power Resources in Manitoba:* The water power resources of Manitoba, both developed and undeveloped, are estimated at approximately 7,500,000 hp at 80% efficiency and 80% load factor. About ¾ of a million hp or about 10% of our total hydraulic resources are located on the Winnipeg River in Southeastern Manitoba, and the remaining 90% or close to 7,000,000 hp of our water power resources are situated in the Northern part of the Province. At the present time, of all the water powers in Northern Manitoba, the site which offers the most encouraging prospect for development for transmission to Southern Manitoba is the Grand Rapids site where the Saskatchewan River enters Lake Winnipeg. At this site upwards of 328 mw can be developed, and the storage capacity behind this site in the Cross and Cedar Lake areas is substantial.

The electrical energy that may be produced at this site is nearly one-half of the total present consumption in Manitoba. This energy production will be made possible by impounding the waters of the Saskatchewan River in a large reservoir with 7,000,000 acre ft. of storage capacity. This 7,000,000 acre ft. of storage capacity is effective on a head of 120 ft. The storage in Lake of the Woods and Lac Seul amounts to 8,500,000 acre ft. and this is effective on a head of 255 ft. for the Winnipeg River system in Manitoba. Both of these storage reservoirs empty into Lake Winnipeg.

The Nelson River which falls through approximately 700 ft. as it travels from Lake Winnipeg to Hudson Bay, offers the richest promise for water power development in Northern Manitoba. Lake Winnipeg, a body of water containing some 18 million acre feet of storage between the elevations of 712 and 715 offers great promise for the development of firm capacity on the Nelson River at all the sites listed in Table I.

In addition to the water resources of the Nelson River there is also the Churchill River with sites available in Manitoba for development. These are detailed in Table II. Mention was made previously of the Island Falls plant on the Churchill River located in Saskatchewan. This plant, No. 40 on Fig. 1, supplies the Hudson Mining and Smelting Company load. This load requires the full output of the Island Falls site, with its accompanying storage on Reindeer Lake, and it is not inconceivable that a tie with the Nelson River site under development at Kelsey or with the Grand Rapids site under development for 1964 will be of substantial importance to the sustained production of mineral wealth from the Flin Flon operation. A cost benefit study on the interconnection with the Island Falls and Kelsey plants is underway.

There is also the Seal River in Northern Manitoba which has some seven sites. These are listed in Table III. The balance of the better known sites in the Province are listed in Tables IV, V and VI. There are innumerable other sites, some on the Burntwood River, in the capability of ten to thirty thousand hp, as well as innumerable other sites in the Eastern part of the Province on the rivers that

TABLE I
Nelson River Power Potential

Key	*Site*	*Head in Feet*	*Peak* Megawatts Available at 80% Efficiency and 80% Load Factor*
1	Whiskey Jack	25	140
2	Whitemud Falls	41	228
3	Red Rock Rapids	30	166
4	Kelsey	50	277
5	Birthday Rapids	33	183
6	Upper Gull Rapids	24	133
7	Lower Gull Rapids	34	190
8	Big Hill Rapids	38	210
9	Kettle Rapids	54	300
10	Long Spruce Rapids	69	383
11	Lower Limestone Rapids	186	1,030
12	Above Gillam Island	70	388
		654	3,628

*Based on regulated flow with 3 feet of storage on Lake Winnipeg. Output power at the generator terminals.

TABLE II
Churchill River Power Potential

Key	*Site*	*Head in Feet*	**Peak Megawatts Available at 80% Efficiency*
13	Pukatawagan Falls	30	50.8
14	Granville Falls	40	68.0
15	Missi Falls	40	68.0
16	God's Rapids	40	68.0
17	Fidler Lake Rapids	120	203.0
18	Head of Upper Canyon	155	262.0
19	Above Lower Canyon	130	219.0
20	Below Lower Canyon	75	127.0
21	Below Old Beach	70	119.0
22	Limestone Rapids	40	68.0
		740	1,244.8

*Output Power at generator terminals.

empty into Lake Winnipeg, but most of these have very limited storage and do not appear economic under present known conditions. However, as time passes and more information about our natural resources is gathered, then it is to be expected that certain of these sites will become economically attractive for one reason or other.

(b) *Developed Power Resources Adjacent to Manitoba:* Fig. 1 shows the developed hydraulic sites on the English and Winnipeg Rivers, and the Garrison Dam site on the Missouri River in North Dakota. These with their known installed capacities are listed in Table VIII.

(c) *Power Exports:* Manitoba is at present interconnected at 138 kv with the North West Region of the Hydro Electric Power Commission of Ontario, and a 230 kv tie is under construction between Brandon and Estevan to interconnect the Manitoba System and The Saskatchewan Power Corporation system. This tie will operate initially at 138 kv but full provision is being made for operation at the 230 kv level when conditions warrant.

These interconnections make possible the day to day scheduling of interchange power to the mutual benefit of all parties of the interconnection.

Capacity purchases are also possible on a short term future basis to help the development of the interconnected systems.

The Manitoba Hydro-Electric Board has been aware of the growth of the power facilities to meet increasing loads in the area south of the 49th parallel. The long range program for the Dakotas alone indicates that the 20 yr. power planning program for this area requires an additional 1500 mw by 1980, in addition to that power which is planned. The latest information[2] indicates the following:

State	1958 Installed Capacity in Megawatts	
North Dakota....	507	
South Dakota.....	543	
Total Dakotas....		1050
Minnesota........	1947	1947
Total Dakotas and Minnesota......		2997

This means the Dakotas alone will have an installed capacity of close to 3000 mw in 1980. The growth of the electrical systems in the northern part of the central United States will require the extension of the 230 kv transmission system. This is now at Fargo some 225 miles from Winnipeg and at Garrison Dam some 175 miles from Brandon which is in reach

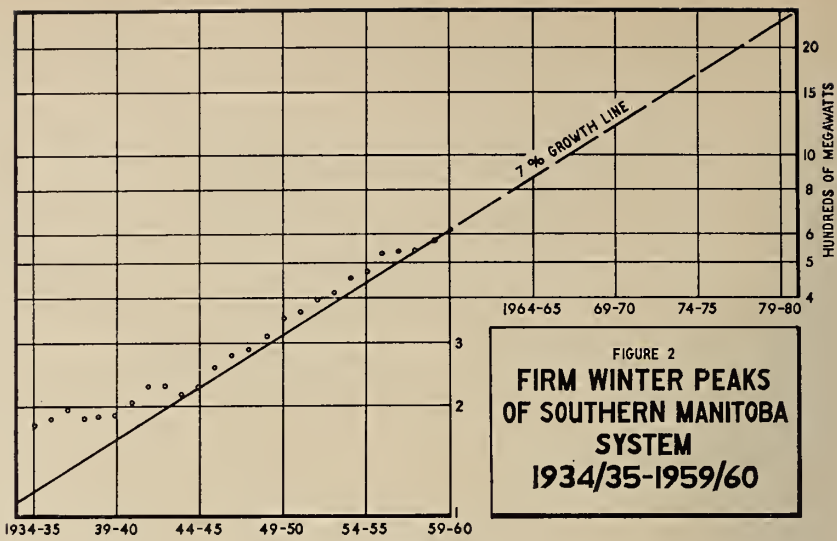


Fig. 2

of The Manitoba Hydro-Electric System. The prospect of development of a large thermal generating station supplied directly from the coal seams adjacent to the Missouri River and the installation of large size units is under study. This thermal generation could be of assistance to Manitoba in the future. In addition, it would provide a ready market for an equichange agreement to be established with the appropriate authorities in the Dakotas for disposal of some of Manitoba's abundant hydro-electric energy and to a considerable degree, justify the high initial costs of transmission from the Nelson River sites in Manitoba.

On the basis of installing capacity at Northern sites, prior to the indicated need of the Southern areas, the power could be made available to the Northern States on a share capacity basis, which, under the terms of the National Energy Board[3] might be classified as plant construction diversity.

Under these conditions energy might be made available at the border at an incremental cost of between .75 mills and 2.25 mills depending upon the amount of energy required and upon the reliability of the interconnection for disposal of this energy. This analysis is based on average flow conditions. Should very low stream flows be experienced in the two watersheds now being considered by The Manitoba Hydro-Electric Board (Lake Winnipeg excluded) then no surplus energy would result. However, the abundance of thermal-energy south of the line might serve as a firming source for the future Nelson River Manitoba Hydro installations. On the other hand when above average stream flows result, large volumes of dump energy could be available at very attractive rates to any thermal producing utility.

(d) *Project Evaluation:* It has been our policy in selecting a new source for development to study various sequences which will provide the most economic power available to the system as a whole, when fully integrated with the existing resources. Consequently in order to properly assess the economics of a project, a study of the system growth and costs for a considerable period of time into the future must be made and these various component costs brought to a "present worth" basis. The date on which this present worth comparison is made is really of little consequence providing all costs are brought to the same common denominator. This common denominator is important and should provide for a means by which the effects of later additions may be eliminated. In order to eliminate the influence of later additions these should be the same for all sequences compared, as far as practicable, or reasonable, beyond the date of cut off.

We believe in evaluating projects that the sinking fund method is the most equitable of all methods of analysis. The development and significance of this sinking fund method, as compared with the straight line depreciation method, is outlined in the attached Appendix.

It is readily appreciated that most hydro developments of large capacity can best be justified if a load building period is overcome either by:

1. The temporary purchase of capacity;

2. The sale of energy or capacity from a new hydro plant through interconnections with other utilities, and this can then be recaptured as the developing utilities load grows to the

point where it can be absorbed within the system.

In Manitoba, the cost of future hydro-electric development, the closest of which (Crand Rapids) is some 250 miles from the Winnipeg load area and the furthest of which is some 600 miles from the Winnipeg load arca, is in the category of marginal economic justification without some prior load building when compared to thermal capacity with present costs.

(e) *Tools:* In Manitoba, to assist in planning the electrical system development, The Manitoba Hydro-Electric Board has installed an A.C. Network Calculator. This unit has the following number of components: 12 generators, 138 impedance units, 24 pi-line units, 60 capacitor units, 72 load units, 18 mutual transformer units and 9 autotransformer units. It also has automatic watt regulators on generators, automatic scale selection on the Master Instruments[4] and a recording table.[5] This calculating board was installed in August 1959, and has been in continuous operation since that time and the planned work load for it will take many more months of time. It is expected then, that this Calculator will be available for use by other than the utilities of Manitoba.

The other components of system development involving the hydraulic work are carried out by utilizing simulation study techniques, and these are best handled by digital computers. This was the case in the determination of some of the hydraulic characteristics for the Grand Rapids site; this work was performed on an IBM 704 Machine. The hydraulic group do simulation studies by hand, when the justification for digital computer use cannot be made.

As any power system develops, so do the number of problems associated with its planned growth, its daily operation, its most efficient use of hydro storage, and thermal capacities, and the minimization of system transmission losses. All of these factors become more complex, and more dependent upon judgment, than upon the ability of man to compute proper results by analytical determination, hence, it is for these reasons that most complex power system developments are aided by mechanical-electrical machines.[6, 7] The combined complexity of both the hydraulic analysis and the electrical analysis of a system point to a greater utilization of the digital computer. These machines assist the Planning people in their task of providing a reliable system to produce energy at minimum cost. There are many systems in the world which have integrated hydro and thermal resources[8] but a careful review of the literature[9] that has been printed to date indicates that there are effectively no two systems with the same basic problems. The development of the rule curves of operation of storage reservoirs is a problem to which there is no easy answer. The answer lies in the installed capacity, the available interconnections and the load and incremental energy cost pattern of the utility which has this storage available for its energy production.

System Development

The next step to meet our expected load growth for 1963 is to be a capacity purchase from the Saskatchewan Power Corporation. This was under negotiation at the time this paper was prepared. Consequently, the first new capacity that Manitoba will bring in above the present capability for the Southern System of 850 mw will be a hydraulic installation at the Grand Rapids site where the Saskatchewan River emptics into Lake Winnipeg. This Grand Rapids plant probably would have an initial installation of two units each rated at 82 mw, 0.95 p.f., 13.8 kv. Propeller turbines appear at this stage to be the economical choice. These, we believe, would be the largest fixed blade propeller type units made to date by any company. Studies are continuing on economic setting, F.S.L. and a number of other factors which must be settled before construction can be undertaken at this site.

The selection of Grand Rapids is the result of a consideration of many alternative sites and many alternative sources of generation. Introduction of the Grand Rapids power into our present system which is predominantly 110 kv. has been settled on the basis of three 230 kv. lines. Essentially, it is desirable to have this 255 miles of transmission line operate at the highest voltage practicable. However, there are operation and design problems associated with system development which have resulted in thc choice of a 230 kv. voltage level to inject this Grand Rapids power into the Southern System. One of the predominant reasons for the 230 kv. voltage level in preference to a higher voltage line has been the line charging requirements. These point to the installation of the largest generator possible at Grand Rapids and the proposed units of 86 m.v.a. will satisfy the line charging requirements provided suitable shunt reactors are installed at the Winnipeg end of these transmission lines.

Present plans call for subsequent units to be installed in 1965 and 1966 bringing the plant to a capacity of 328 mw, with provision for a 5th and 6th unit. The final number of units for this site is dependent upon further studies. The establishment of the 230 kv. connection between Winnipeg and Brandon is planned for completion in the year 1962. The 230 kv. switching station at Steep Rock will permit a 230 kv. tie with the Saskatchewan Power Corporation's Northern System, where they are engaged in developing a hydraulic site at Squaw Rapids on the Saskatchewan River. It will also provide a supply point for the Interlake loads. Following the development of the Crand Rapids site there are several alternatives for future power. These are as follows:

1. An extension of the Selkirk Thermal-Electric Plant;

TABLE III
Seal River Power Potential

Key	*Site*	*Head in Feet*	**Estimated Peak Mw Available*
23	North Seal River	60	5.4
24	Below Shethanei Lake Site #1	60	20.4
25	Below Shethanei Lake Site #2	60	20.4
26	Above Great Island	115	39.0
27	Great Island	95	32.2
28	Below Great Island	100	33.8
29	Between Great Island and Hudson Bay	110	37.4
		600	188.6

*Output power at generator terminals.

TABLE IV
Saskatchewan River Power Potential

Key	*Site*	*Head in Feet*	*Available Megawatts at 80% Eff. and 60% L.F.*
30	Grand Rapids	120	328.0

TABLE V
Laurie River and Island Lake River Installed Capacity

Key	*Site*	*Head in Feet*	*Normal Winter Capacity in Megawatts*
31	Laurie River No. 1	55	5.2
32	Laurie River No. 2	55	5.2
39	Kanuchuan	50	1.4
		160	11.8

2. An extension of the Winnipeg River generating capacity;

3. Development of the Nelson River power;

4. Addition of nuclear units.

Selkirk: The site at Selkirk where The Manitoba Hydro-Electric Board will have two 66 mw units installed at this time is capable of being developed to a million kw. The injection of this additional power into the system will probably be made at the 230 kv. level, and connected into the present system at the Rosser Road and St. Vital Terminal Stations where substantial interconnections with several 110 kv. circuits are provided for.

Extension of Winnipeg River Generation: Future development of the Winnipeg River has three major aspects:

(a) Full utilization of energy resources;

(b) Development of peaking capacity;

(c) Development of Spinning Reserve.

While detailed engineering studies have not been completed to date, one attractive scheme for utilization of this river to fill the role outlined above would be the re-development of the upstream plants in Manitoba in such a manner as to reclaim some undeveloped head and to utilize to the maximum the upwards of 10 sq. miles of forebay that are available.

The Winnipeg River plants are designed for a flow of between 23,000 and 36,000 sec. ft., hence by redevelopment and bringing all plants to the same designed load factor, capacity and energy could be realized.

The load factor to which the downstream plants may be developed need only be limited by the hydraulic problems associated with the reaches of the river between these plants.

The Manitoba system which is predominantly composed of fixed blade propeller units must rely on these units operating at relatively low efficiencies to provide spinning reserve, or alternatively rely on thermal units with their associated expense.

The re-development of the Winnipeg River plants for peaking purposes and full utilization of energy resources may well be accompanied by the introduction of Kaplan or other variable pitch blade units to economize on water, particularly in low flow years. Such units would provide efficient energy with a good spinning reserve component. One upstream site on the basis of preliminary investigations would have 225 mw of installed capacity to provide the system with spinning reserve at a reasonable cost. The price would be between $200 and $250 per installed kilowatt on the basis of present day costs.

The programmed installation of additional capacity in the upstream Winnipeg River plants would be followed by a systematic re-development of all downstream plants in such a manner as to have them all conform with this new role.

This peaking capacity associated with the re-development of the Winnipeg River is planned to be delivered into the present system at the 230 kv. level. This would leave the present 110 kv. system to supply local loads, and in addition they would assist the 230 kv. transmission system during peak operation periods. The introduction of the 230 kv. transmission will result in a considerable reduction in transmission losses from Winnipeg River to the Winnipeg load area.

It is quite evident that the full re-development of the Winnipeg River cannot proceed without being co-ordinated with the first and the third alternative sources of new generation or alternatively with nuclear energy development for Manitoba.

Development of Nelson River Power: The fact has been established that the Nelson River represents one of Manitoba's best possible sources of power, with storage capabilities on Lake Winnipeg to permit an installed capacity of upwards of 3,800,000 kw. at 80% efficiency and 80% load factor operation. Some of the major problems associated with development of Nelson River power are of course the site construction difficulties.

We have found in the development of the Kelsey plant that permafrost poses a formidable problem in power development at Nelson River sites. It is not proposed here to enter into a discussion on the construction aspects of development of Nelson River power, except to say that these may have an influence on future development on this river.

Delivery of power from the Nelson River in the magnitudes in which it is available would indicate that the 230 kv. transmission network proposed and economical for the job, which it is being developed to do, would not be the most satisfactory voltage for Nelson River power delivered to Winnipeg.[10] It is proposed that the majority of this transmission would be on the east side of Lake Winnipeg. Using 460 kv. and the difference in distance coming around via Grand Rapids instead of the east side of Lake Winnipeg results in an estimated additional cost of $140 million on a present cost basis. There are many difficulties to overcome in construction in this area which is predominantly muskeg and rock country. The route of these 460 kv. lines may provide part of the tie for the proposed cross Canada transmission line,[11, 12]

Addition of Nuclear Units: The establishment of the Whiteshell Atomic Research Station in Manitoba will provide an opportunity for engineers of The Manitoba Hydro-Electric Board to keep abreast of developments in the nuclear energy field. It may well be that by 1970 this source of energy will be a major contender with Nelson River Power. Manitoba is co-operating in every manner possible toward a sound engineering and economic assessment of this source of energy.

Conclusion

In addition to some of the hydraulic and electrical planning which has been outlined and the presentation of the basis on which projects should be evaluated, the writer has attempted to give a picture of the long range planning that is necessary in order to properly develop and evaluate the growth of the electrical industry in Manitoba. There are many other aspects of this job which have not been mentioned but which will be investigated as time and man power become available.

Acknowledgement

The author wishes to acknowledge the valuable assistance of members of The Manitoba Hydro-Electric Board System Planning Department.

APPENDIX

Economic Factors Affect System Development

Engineering is closely allied with economics—normally a development program must pass the acid test of economic analysis. When considering new generation for an electrical utility, it is very important to assess the cost of energy production for a number of years ahead. The paper has stated that we believe in project evaluation using the Sinking Fund Method. It is proposed here to discuss the Straight Line Method of depreciation and the Sinking Fund Method and to emphasize the desirability of using the Sinking Fund Method for project evaluation.

Classical accounting usually claims that a system to be "in balance" must have assets in a form represented by physical plant or cash reserves and not be dependent on the earning power of a fund which is subject to changes in interest rate and amount of earning each year.

Many utilities have a practice of using

one method of evaluation for System Planning purposes and an entirely different method of bookkeeping for annual statements.

It is not intended here to propose changes in Annual Statements which are usually made in conformity with the tax laws of the land, but to recognize the importance of proper evaluation of new projects on their acceptance or rejection as economic energy producers.

The Straight Line Method of depreciation in Planning studies results in a distorted picture of the merits of high capital investment, long life, and low operating costs for a hydro site as compared to low capital investment, short life and high operating costs of a thermal development.

It is assumed here that:

1. Hydro sites have a life of 44 years;
2. Thermal - electric developments have a life of 25 years;
3. The cost of money is the same for both projects;
4. The purpose of a depreciation charge is to recover the original investment at the end of the assigned life, (assuming no salvage value).

Straight Line Depreciation: In the Straight Line method, the average annual depreciation charge is the original investment cost divided by the life in years. For example, if the investment cost of a hydro plant amounted to $100 million and the life 44 years, the annual computed depreciation charge of 2.27% would be $2,273,000. If no improvement rate is assigned to this fund in the books, the accumulation will result as shown in the graph Fig. 3, Curve A.

A corresponding thermal plant of equal capacity is assumed to cost $40 million and has an assigned life of 25 yrs. The annual computed depreciation charge of 4% would be $1.6 million. The accumulation will result as shown on (Fig. 3) Curve B.

Payments in either case may be made monthly or annually, in which case the curve could be made to indicate the stepped nature of the payments. This refinement is not shown.

There are variations in the Straight Line Method. The curves of Fig. 3 assume no earning on the Fund, and depreciation charges were computed annually on the original investment. Two alternatives might now be considered.

1. That the depreciation account money earns interest at 5% and would produce an amount of $340 million at the end of the useful life as shown by Curve C of Fig. 4, as compared to the original capital cost of $100 million. This earning could be attributed to the fact that the Depreciation Account might be invested in new plant or in liquid assets for the reserve Account. Curve D of Fig. 4 indicates the growth at 3.5%, while Curve A may be thought of as 0% improvement rate.

2. That the original capital investment is written off each year by the amount of the depreciation charge resulting in a reducing charge against the system each year. This is contrary to normal financing as the book value of assets to secure the bonds on the original investment would be changing each year. It is true that part would be in plant and part in a depreciation account, but we believe in general, accounting practice does not utilize this method and hence, it is not considered further.

Sinking Fund Depreciation Method: In the Sinking Fund Method, a constant amount of money is set aside annually and is assumed to earn interest at a rate equal to the average cost of money over a period of years. This fund may also be invested in part, in new plant which would then be earning interest at the going cost of new money.

For example, if we assume 25% of the Sinking Fund is invested in bonds bearing 4% interest and 72.7% invested in new plant, permitting the reduction of borrowing for that plant which otherwise would have been done at say 5½%, the remainder of the Sinking Fund average 2.3% is left in the Current Account where it may be thought of as idle cash.

Combining the above 3 rates:

$$\begin{aligned} 0.25 &\times 4\% = 1.0 \\ 0.727 &\times 5.5\% = 4 \\ 0.023 &\times 0\% = 0 \\ 1.0 & \qquad = 5\% \end{aligned}$$

Thus the Sinking Fund improves at 5%.

The annual amount must then be set aside to accumulate the Plant "first cost" ($100 million in this case) after a period of 44 yrs. with the average improvement rate of 5% computed as follows:

If:

1 is the annual amount of depreciation,

i is the interest on the annual amount of depreciation at year end.

Sn is the original investment to be recovered at the end of the nth year.

Then $$Sn = \frac{(1+i)^n - 1}{i}$$

$$Sn = \frac{(1+0.05)^{44} - 1}{0.05}$$

$$= 152.0$$

These computations can easily be performed on a log – log slide rule. The interest on the original investment is charged separately as annual payments or bonds, say, to whatever rate the money is raised.

From the above, the constant annual depreciation charge amounts to

TABLE VI
Winnipeg River Installed Capacity

Key	Site	Head in Feet	Installed Capacity in Megawatts	Normal* Winter Capacity in Megawatts
33	Pine Falls	37	85.1	82
34	Great Falls	58	125.0	132
35	McArthur Falls	23	59.7	56
36	Seven Sisters	61	168.0	150
37	Slave Falls	30	71.6	68
38	Pointe du Bois	46	78.5	72
		255	587.9	560

*At the generator terminals.

TABLE VII
Steam Plants Installed Capacity

Key	Site	Installed Capacity* in Megawatts
48	Selkirk	123
49	Amy Street	45
50	Brandon	122
		290

*With station service deducted

TABLE VIII
Developed Power Resources Adjacent to Manitoba

Key	Site	River	Head in Feet	Normal Capability Megawatts
43	Caribou Falls	English River	58	76.2
44	White Dog Falls	Winnipeg River	50	61.4
45	Lake of Woods	East Outlet	21	9.0
45	Lake of Woods	West Outlet	20	14.1
46	Manitou Falls	English River	54	69.0
47	Ear Falls	English River	36	18.6
40	Island Falls	Churchill River	56	93.6
41	Squaw Rapids*	Saskatchewan River	112	202.0
42	Garrison Dam†	Missouri River	170	240.0

*Under development.
†Provision for additional 160 mw.

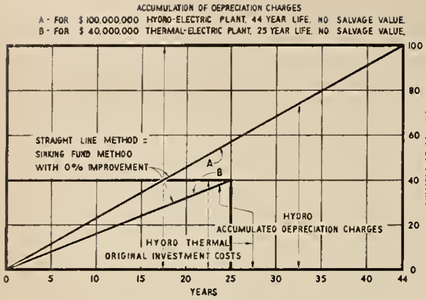


Fig. 3 Accumulation of Depreciation Charges by Straight Line Method.

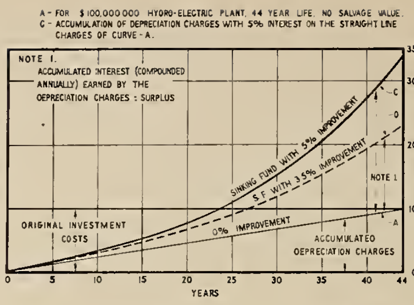


Fig. 4 Accumulation of Depreciation charges by Straight Line Method with various rates of improvement.

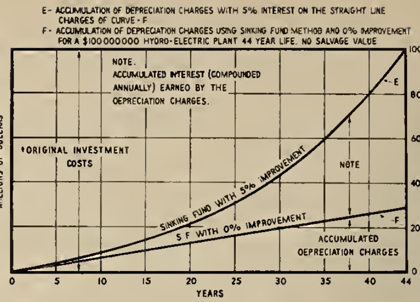


Fig. 5 Accumulation of Depreciation charges by Sinking Fund Method.

$$\frac{100{,}000{,}000}{152.0} = \$657{,}000$$

or say 0.657%.

The accumulation of the constant annual payments with earnings (average improvement rate of 5% from above) is shown in Fig. 5, as Curve E.

The thermal plant of equal capacity considered above would have an annual payment to depreciation account for Sinking Fund of

$$Sn = \frac{1.05^{25} - 1}{0.05} = \frac{3.39 - 1}{0.05} = 47.8$$

$$\text{or} \quad \frac{40{,}000{,}000}{47.8} = \$836{,}000 \text{ annually.}$$

Which is equivalent to an annual charge of 2.09%.

Comparison of the Two Methods: It can be seen that the reduction in annual depreciation charge from Straight Line to Sinking Fund amounts to

(2,273,000 − 657,000) = 1,616,000

for the Hydro Plant and

(1,600,000 − 836,000) = 764,000

for the Thermal Plant. Expressed as percentage of the investment costs, the reduction amounts to

(2.27 − 0.66) = 1.61%

for the Hydro Plant and

(4.0 − 2.09) = 1.91%

for the Thermal Plant.

Since the money set aside each year for Depreciation Reserve will be used by the organization for whatever use is demanded of this money within the tax laws of the country, it follows that a careful look at the Depreciation Reserve Account should be made. The fund need not provide for any more than a repayment of the original Plant costs at the end of the assumed life of the plant; to provide more is charging today's power consumer with tomorrow's plant.

In the hydro plant example, the Straight Line annual payments would amount to

$$100{,}000{,}000 \times \frac{2.273}{0.657} = \$346 \text{ million}$$

at the end of the useful life with 5% interest earnings compounded or $246 million surplus after 44 years. This is illustrated in Fig. 4, Curve C.

In the thermal-electric plant example, the Straight Line annual payments would amount to

$$40{,}000{,}000 \times \frac{4}{2.09} = \$76.5 \text{ million}$$

at the end of the useful life, with 5% interest earnings compounded or $36.5 million surplus after 25 years.

Since a system has capacity additions made every few years to keep it abreast of the load growth, it is easy to lose sight of these excessive Straight Line Depreciation charges. They result in accumulation of reserves beyond the original cost of the plant they are set aside to repay, hence the importance of the method of treating depreciation in project evaluation.

The straight line method overstates the annual charges which are associated with a high capital cost and long life project when compared with a lower capital cost and shorter life project such as a thermal station.

The sinking fund method of treating depreciation for project evaluation takes more adequate account of the virtues of the longer life project and hence serves to provide a more adequate basis of comparison for such alternatives as I have used in the example discussed. Furthermore, it avoids the overstatement of the annual charges by having no inherent surplus.

The sinking fund method of treating depreciation for project evaluation is equitable to all alternatives of new capacity installation and is therefore recommended[13,14,15,16] for project and sequence evaluation in forward planning studies.

This is not to say that for utility accounting purposes where the books of a utility may be required to deal with a whole complex of Plants and Properties that the straight line method of depreciation is necessarily inappropriate. This derives from the fact that in the field of utility accounting the tendency towards overstating the depreciation costs of a particular project such as might be inherent in the straight line method of depreciation, could be partially or perhaps even fully offset by the manner in which depreciation reserves are employed by the utility.

While the author's views on this subject have been stated with some assertiveness, it has been done with the hope that it may elicit a discussion on this. The general question, we believe to be of sufficient importance to warrant the best and most informed views that can be brought to bear upon it for these purposes. An exchange of views and practices on the general question of the treatment of depreciation for project evaluation in System Planning Studies might prove helpful to all who are concerned with power utility economics.

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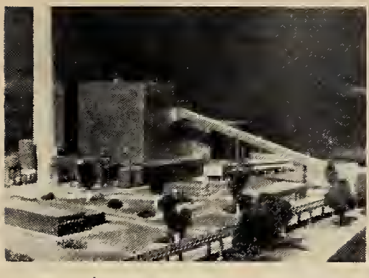

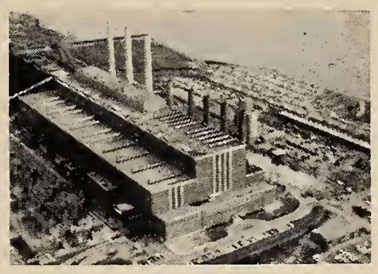

LAKEVIEW & R. L. HEARN GENERATING STATIONS DESIGN

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This article covers salient design features of two modern thermal power stations of the Hydro-Electric Power Commission of Ontario. Its purpose is to show how the design of the Lakeview Generating Station has evolved from the basic requirements and criteria established for the plant, and how it compares with that of its predecessor, the Richard L. Hearn Generating Station Extension. Design features discussed include turbine inlet steam conditions, turbine exhaust annulus area and condenser size, and steam generator efficiency. The addition of thermal units to a predominantly hydraulic generating system results in two unusual basic criteria for large modern thermal units—an expected low lifetime capacity factor and a requirement for daily start/stop operation. The influence of these criteria is considered with particular reference to centralized control arrangements and to the unusual design provision of a steam bypass system which facilitates rapid starting of the plant.

THE design of a modern thermal power plant for proper integration into a complex electric utility involves an effort of hundreds of thousands of man hours and a vast complex of administrative and technical judgments extending over a period of several years. Such judgments range from those which establish the need for the plant through those which determine the basic criteria of design to thousands of individual decisions, principally of a technical nature, which in the end form the detailed design.

It is the purpose of this paper to present an outline of some of the more important judgments taken in connection with the design of a particular plant—Ontario Hydro's Lakeview Generating Station—to illustrate how the salient design features of that plant have evolved from the basic requirements and criteria established. By way of comparison, the main design features of the R. L. Hearn G. S. Extension, the predecessor to Lakeview G.S., are also given.

Need for Additional Thermal Plant

The need for the Lakeview Generating System was established and approved by June, 1957. At that time two hydraulic plants—Sir Adam Beck Niagara Generating Station No. 2 and St. Lawrence G.S.—representing an installed capacity of 2,310 Mw. were well advanced. An additional four 200 Mw. units at the R. L. Hearn G.S. had been committed for completion by the end of 1960. Nevertheless, the relatively constant annual growth exceeding 6%, coupled with a decision to bring power reserves up to a figure of the order of 12% indicated that an additional 500 Mw. of generation would be desirable in 1961, followed by a further increase of 300 Mw. in 1962.

Since all of the major hydraulic sites in the southern Ontario system were either developed or in progress, two basic alternatives for additional generation were open. The first was to develop hydraulic sites in Northeastern Ontario, particularly on the Abitibi, Mattagami and Missinaibi Rivers. The second was to embark on a new thermal plant in the southern Ontario system suitably close to the main load concentrations. Further expansion of the R. L. Hearn G.S. above the 1200 Mw. rating already committed was considered to be undesirable at that time, from the standpoint of site area and problems of power takeout.

Although the detailed information on the northeastern Ontario sites was relatively limited from the standpoint of surveys and preliminary engineering analyses, the information available pointed to the following characteristics.

1. The most economical long-range development would be as peaking plants to such a degree that their capacity would require firming by energy from thermal plants located elsewhere in the system.
2. The low capacity factor associated with the ultimate rating of such plants was not compatible with system load factor. Thus, progressive increases in peak capacity of several plants would be required over an extended period of time.
3. Because of the large distances from the load centres, and the economic incentive to develop maximum capacity at these sites, the northeastern Ontario generation would require extra-high voltage transmission —expected to be 400 kv. or above— for connection to the main load centres.
4. The capacities of the various hydraulic sites, if initially developed to approximate the system load factor, were small relative to the 800 Mw. required in 1961 and 1962. Thus, simultaneous development of several sites would have been required if the full requirement of 800 Mw. was to have been met from hydraulic sites alone, with the resulting undesirable peaking of engineering work load.

These considerations, in the light of the limited information and advance engineering on those sites led naturally to a basic plan of committing first another thermal plant in the southern system with the intention of integrating with it the development of the northern hydraulic sites on much less of a crash program in order to give more flexibility and a better balanced work load.

It was on this basis that the requirement was established to start a new thermal plant. Subsequent studies on the hydraulic sites have supported this decision.

Determination of Basic Characteristics

Having determined the need for the plant, the next step was to establish some of its basic characteristics.

As far as unit rating was concerned, the principal considerations were capacity required by or acceptable to the system and availability of large-capacity turbine generators. Ontario Hydro had already experienced a trend from 60 Mw. units installed at the J. Clarke Keith Plant at Windsor to 100 Mw. units in operation at the R. L. Hearn plant and on to 200 Mw. units to complete the latter—and this in a period of seven to eight years. The same trend was evident in other utilities as the struggle continued to offset rising costs by increasing unit size. Even at that time there was considerable discussion among utility and manufacturing engineers about 400-450 Mw. units. The choice for Lakeview, inevitably a matter of judging the probable advantages of increased rating against the troubles one may inherit from too large a step, was for 300 Mw. units.

This rating seemed likely to be acceptable from a system security standpoint. It represented a 50% increase from the rating of the larger Hearn units and was likely to offer substantial cost reductions in both unit capital and unit energy costs. Because U.S. utilities already were committed to units of approximately this rating which are now installed, this decision may not be considered very venturesome. However, because of a very important price advantage which prevailed for units of other than American manufacture, it seemed highly unlikely that a U.S. machine would be purchased and at that time no manufacturer outside the U.S. had produced even a 200 Mw. unit.

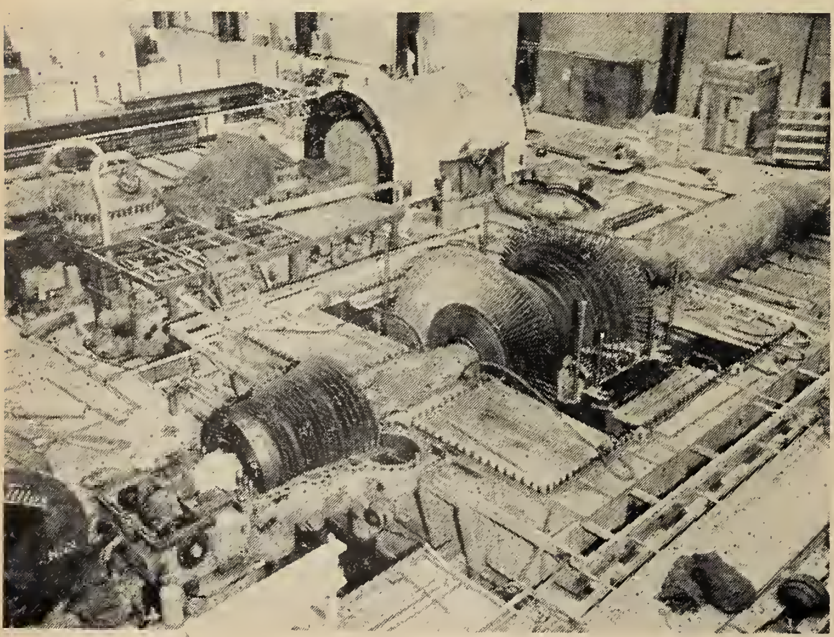
Another important factor in setting the basic requirements for the units was the probable type of operation. From system peak load and energy load studies it was evident that, at least in the initial years, the plant would be operated at relatively low annual capacity factor since energy from the thermal plant was known to be more expensive than energy from existing hydraulic plants. In later years of operation the annual capacity factor at which the units might operate is, at best, a guess. However, the probability that growth in base load thermal power will be derived largely from nuclear plants after 1970 and the continuing technical advance in the efficiency of thermal plant both point toward a relatively low lifetime capacity factor. For this reason it was considered that the new thermal plant should be designed for daily start/stop operation and should not necessarily be designed for the maximum efficiency available at the time. On the other hand, the 300 Mw. rating itself demands relatively high steam conditions and could be expected to give a plant of reasonably high efficiency if it should become necessary to operate close to base load.

Another basic consideration to be settled was the question of maximum plant capacity. This value was chosen largely on the basis of comparing very long-range load projections in the high load density Toronto-Hamilton belt with the probable number of suitable sites which could be acquired. Other considerations included the relationship between plant capacity and system capacity at time of completion, and also the question of what maximum power concentration might be permissible from the standpoint of effective dispersion of stack effluent. The probable full plant capacity selected was 1800 Mw. representing a 50% increase over the Hearn G S. capacity, but with the proviso that, if practicable, the site should be selected and the plant so designed as to allow for expansion to an ultimate capacity of 2400 Mw.

The choice of fuel for the plant was relatively simple. Although major supply facilities for both oil and natural gas were either installed or being installed in the areas containing the main load centres of the system, there was no evidence that either of those fuels would compete economically, at least in the early years of plant operation, with coal imported from the United States as a basic fuel for the plant. This is hardly surprising in view of the anticipated low capacity factor for the plant and the high investment incurred by suppliers for transport and storage facilities for gas and oil. However, it seemed probable that, over the lifetime of the plant, the use of surplus gas at various times of the year might prove advantageous. Therefore it was decided that the plant would be coal fired but that minimum economic provision would be made to accommodate the installation of gas-firing facilities in the future.

The last item in the general specification for the plant was location. Extensive field and office studies were made of alternative sites along the shores of Lake Ontario and Lake Erie. Numerous factors were taken into account in those studies including foundation conditions, costs of dock facilities, effect of shore conditions upon maintenance of clear ship channels and water intakes, water temperature conditions, access for railway and transmission circuits, transmission losses and several others. From these studies, the potential sites were ranked in order of preference and the clear first choice was a site on the western portion of the Long Branch Rifle Ranges in Toronto

Fig. 1 R. L. Hearn Turbine Generator in process of erection.



Township. It offered good foundation conditions, proximity to a high load density area and railway facilities, and reasonably easy access to existing transmission except for a short section across the Queen Elizabeth Highway and a new shopping centre.

On the basis of subsequent load forecasts, it was decided in 1959 to commit two additional units for in-service dates of 1963 and 1964 respectively. The basic specification was not changed with respect to this extension of the original commitment.

In summary, then, the basic characteristics determined for the plant are:

Unit capacity—300 Mw;

Initial plant capacity—two 300 Mw. units, one in 1961, the second in 1962, subsequently extended to include two more units of identical rating, the third in 1963 and the fourth in 1964.

Ultimate plant capacity—1800 Mw. nominal with site to be acquired so as to permit possible later expansion to 2400 Mw.

Type of operation—low lifetime capacity factor with daily start-stop operation.

Fuel—coal with minimum provisions for adding gas firing in the future.

Location—Long Branch Rifle Ranges, Toronto Township.

Arrangements for Engineering Work

With the need and basic characteristics for the plant established, it was necessary to decide upon arrangements for the design work. At that time, Ontario Hydro's organization included only a small group of staff connected with thermal plants at Windsor and Toronto which had been contracted, and this staff group was inadequate to undertake the overall engineering of the new thermal plant. However, since it was evident that in the future much of the load growth would have to be supplied by thermal plant, either conventional or nuclear, Ontario Hydro decided to develop an engineering organization to undertake such work and to assign to it the design of the Lakeview G.S.

Recognizing that proper engineering for such a plant would present sufficient problems even for an experienced design organization let alone one which was just developing, Ontario Hydro retained the services of Stone and Webster to share in the responsibility for the success of the Lakeview Project. Basically the Consultant's terms of reference are:

First, to act in a coaching capacity to ensure the development of an organization within Ontario Hydro competent to handle future thermal plant design and construction;

Second, to provide advice and guidance on engineering and administrative matters in connection with the project;

Third, to provide, from the resources of its own organization any engineering effort which might not have been suitably developed at the proper time by the Ontario Hydro.

Although such an arrangement between a client and a consulting engineering organization may be regarded as rather unusual, experience over the past three years has shown it to be most satisfactory.

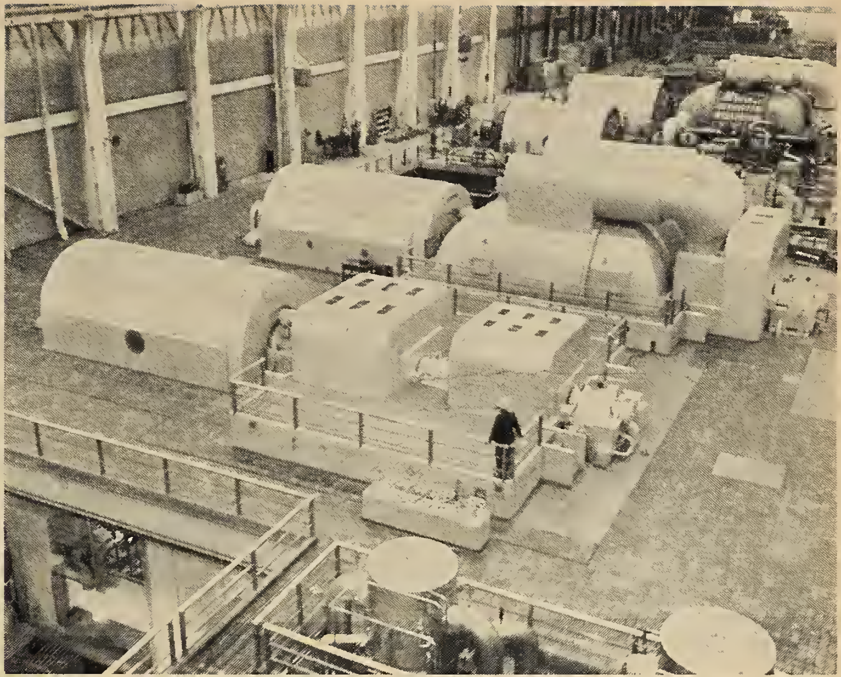


Fig. 2 R. L. Hearn Turbine Generator erected.

Economic Criteria for Engineering

Another class of decision necessary to establish an orderly basis for engineering is what might be called the criteria by which engineering economics are to be assessed. In this case, consistent with Ontario Hydro's policy of attempting to supply power demands with satisfactory service at minimum cost, the over-riding criterion is to obtain the minimum combination of fixed charges on investment, fuelling costs and operating and maintenance costs consistent with high availability. Typical interpretation of this basic criterion is outlined as follows:

1. Both fixed and variable costs as well as expected performance and reliability are to be considered in recommending equipment purchases. The total evaluated cost should normally be used in equipment selection, although lowest first cost should govern when evaluated costs are nearly identical, other characteristics being equal. Special emphasis is to be placed on equipment performance under daily start-stop operation.

2. Special provision for plant expansion should be made only when economic. For such assessments, it may be assumed that the ultimate plant capacity will be reached in 1966.

3. Facilities not directly concerned with economy of power generation are to be held to a practical minimum. No premium is to be paid for special architectural effects.

4. Typical cost data to be used in engineering analyses include:

Fixed charge rate on investment—6.3% per annum. Fuel cost—40 cents per million B.t.u. Lifetime capacity factor—0.30.

The relatively low fixed charge rate of 6.3% arises from the fact that Ontario Hydro is a Commission founded by Ontario municipalities and in effect now operates in partnership with them to supply power to the public at cost. Consequently, it pays no corporation profit tax, and new plant construction is financed by relatively low interest rate bond issues. The fixed charge rate includes interest and depreciation.

Brief Description

The immediate predecessor to Lakeview, the R. L. Hearn Extension consists of four 200 Mw. reheat turbine generator units each served by a 1,350,000 lb. per hr. steam generator. The turbine generators are cross-compound, comprised of, on one line, a high pressure turbine and first intermediate pressure (reheat) turbine driving a 100 Mw. generator at a speed of 3600 rpm, and on the other line, a second intermediate pressure turbine and a double flow, low pressure turbine driving a 100 Mw. generator at a speed of 1800 r.p.m. Fig. 1 shows one of the sets during erection and Fig. 2 shows the set after erection is completed. The turbines exhaust to 90,000 sq. ft. surface condensers. Six extraction points are used for water heating. The steam generators are designed to burn pulverized coal with light oil for ignition and warming. Two steam generators are the natural circulation type and two are the controlled circulation type.

The initial installation at Lakeview consists of two 300 Mw. reheat turbine generator units each served by a 2 million lb. per hr. steam generator. Units 1 and 2 turbine generators are similar to the Hearn units except that a quadruple flow low pressure turbine is used instead of a double flow. The turbines exhaust to 125,000 sq. ft. surface condensers. Seven extraction points are furnished for feed water heating. The natural circulation steam generators are designed to burn pulverized coal with light oil for ignition and warming.

At both plants the unit system of one steam generator and auxiliaries serving one turbine generator without interconnections is employed, with the exception of auxiliary services such as service and instrument air and service water for heat exchangers and bearing cooling.

Steam Conditions

The steam conditions for R. L. Hearn Extension are 1800 p.s.i. 1000°F, 1000°F reheat at the turbine, and for Lakeview, 2350 p.s.i. 1000°F, 1000°F reheat at the turbine. Major factors affecting the selection of steam conditions are: expected plant capacity factor, fuel costs, and fixed charge rate. Although these stations have low expected capacity factors, the low capacity factors are offset by the low fixed charge rate. The result is that the combination is approximately the same as for a large number of investor-owned generating systems operating in North America.

The 2350 p.s.i. pressure is economic for Lakeview (whereas 1800 p.s i. is economic for Hearn) because the percentage increase in initial cost is less, and the gain in heat cycle efficiency is greater for the 300 Mw. plant than for the 200 Mw. plant.

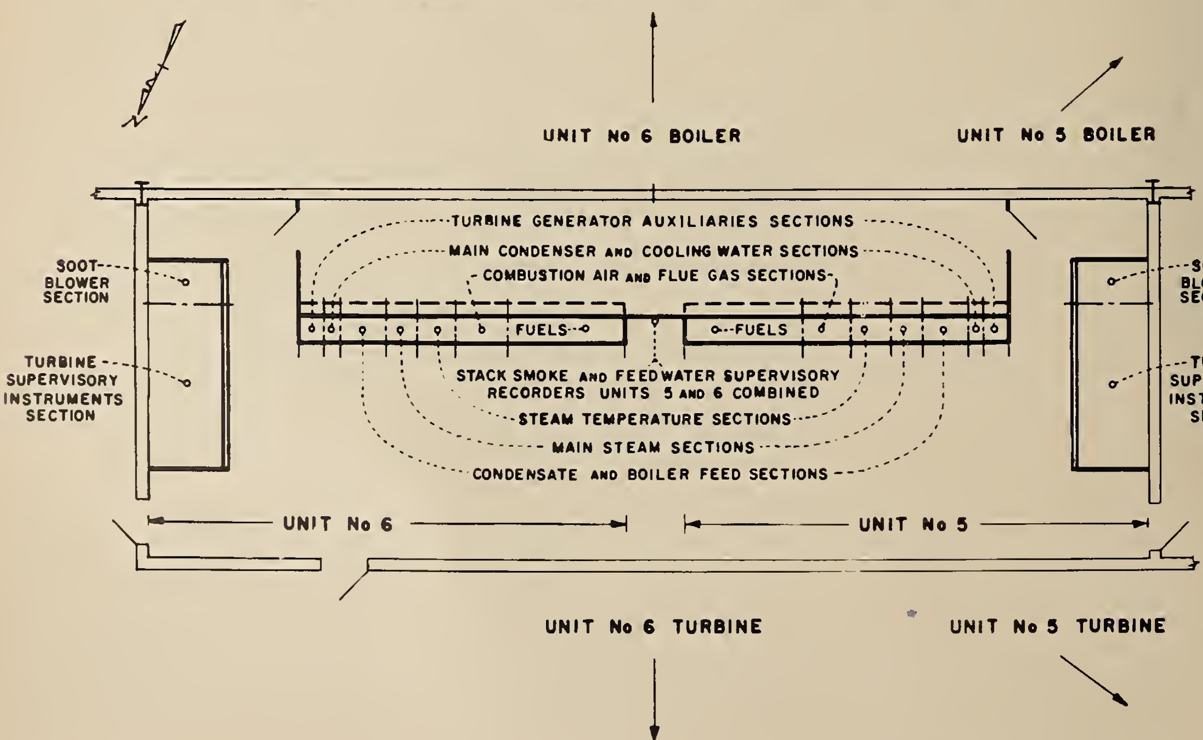
Initial costs for large-size thermal plants are not significantly increased by increases in pressure, because of the reduction in size of portions of major equipment and interconnecting piping. This reduction results from the decrease in specific volume in the steam path and the decreased rate of steam and water flow required for a more efficient higher pressure steam cycle. As a result of the reduction in size, and since pipe wall thickness for a given pressure is in almost direct proportion to pipe diameter, the percentage increase in weight of the piping required is only a fraction of the percentage increase in pressure. Furthermore, temperature rather than pressure dictates the amount and type of expensive alloy materials used. The gain in heat cycle efficiency for a pressure increase from 1800 p.s.i. to 2350 p.s.i. is greater for a 300 Mw. unit than for a 200 Mw. unit, principally because of the relatively smaller shaft and gland leakages for the larger unit.

At Lakeview a further consideration is the limit of pressure at which a natural circulation drum-type steam generator can be expected to perform satisfactorily. This limit is approached at 2,350 p.s.i. at turbine inlet.

The once-through design of steam generator entailed by higher pressures, whether above or below the critical point of 3206 p.s.i.a., involves serious problems in combustion and feed water control, necessitates an extremely high quality of water treatment, and incurs large boiler feed pumping losses. At present the gain in heat cycle efficiency is not sufficient to offset the increases in initial cost associated with the supercritical pressure, particularly when probable loss of availability is considered. Superficial units now operating or under design have been justified mainly as advancements in the art of power generation.

Changes in heat cycle efficiency and initial cost of piping and equip-

Fig. 3 Arrangement of panels in Two Unit Centralized Control Room.



ment due to increases in turbine inlet steam temperature and reheat temperature, can be determined with reasonable accuracy. Fifty degrees F increase in superheat temperature at turbine inlet decreases turbine heat rate by 0.75%, and 50°F in reheat temperature at the turbine decreases turbine heat rate by 0.65%. The present annual fuel saving per unit is $175,000 for superheat temperature and $152,000 for reheat temperature at Hearn, and $252,000 for superheat temperature and $218,000 for reheat temperature at Lakeview.

These are significant amounts of capital. On the basis of somewhat similar savings, a number of units in the 200 Mw. to 300 Mw. range have been designed for 1050°F temperature, and a very small number for higher temperature. However, the selection of 1000°F for Hearn and Lakeview lies largely with the probable loss of availability and replacement cost of superheater and reheater tubing over the life of the plant. These are factors difficult to determine and easy to overlook or minimize. For daily start/stop operation and the attendant difficulty of always accurately controlling furnace exit gas temperatures under rapid start conditions, the expected life of tube materials become even more critical than in the usual case of base load plants. Data now available on some of the 1050°F steam generators in service for several years indicates very short service life for the materials used. Therefore, unless the ratio of annual fuel savings to increase in initial cost is much larger than the normal fixed charge rate, which it is not, it is a prudent course to design for 1000°F.

No implication is intended that steam temperatures have reached a permanent economic maximum. For several years the A.S.M.E. Research Committee on High Temperature Steam Generation have had a testing program for various tube alloy materials at temperatures from 1100°F to 1500°F. Tubes have been tested with 2000 p.s.i. steam at these temperatures for time periods of up to 36 months. The object of the program is to determine the resistance to corrosion and creep, the effects of oxide films on thermal conductivity, the metallurgical stability, and the resistance to thermal shock. From this investigation and others of the sort, metals will be forthcoming with suitable service life. Concurrently the A.S.M.E. Research Committee on the Properties of Steam as part of an international effort is sponsoring research with the aim of ultimately publishing accurate steam properties up to 15,000 p.s.i.a. and 1,500°F.

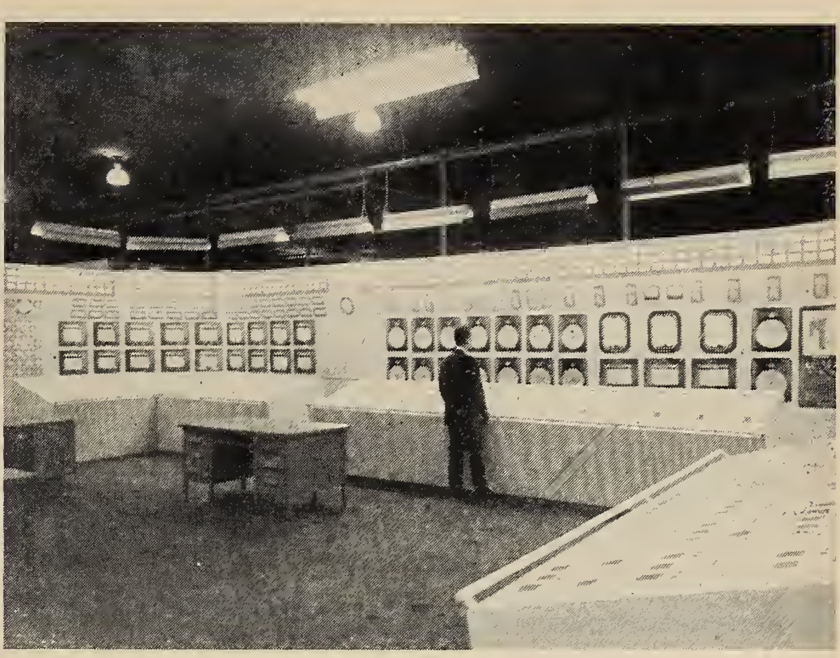


Fig. 4 Mockup of Lakeview Control Room.

As a result of the recent reports on replacement of large amounts of tube surface installed only a few years ago for 1000°F and 1050°F service, tube metal stresses and the maximum temperature limitations on tube alloys were reviewed in detail for the Lakeview steam generator, and limits established somewhat lower and more conservative than indicated by the A.S.M.E. boiler code. The action was taken with the firm expectation that the life of superheater and reheater tubing would be increased considerably.

Turbine Exhaust Annulus Area —Condenser Size

For many years the electric power industry has devoted much attention to the importance of increased pressure and temperature, but until recently it has not devoted the same attention to the gain in kilowatt output and better heat cycle efficiency attainable by increasing the size of the exhaust end of the turbine for locations where cold water is available.

Lake Ontario furnishes an abundant supply of cold circulating water ranging in temperature from 32°F to a maximum, except under extreme conditions, slightly above 60°F. With circulating water available at these temperatures it is usually economic to achieve increased heat cycle efficiencies by the selection of a turbine with a liberal exhaust annulus area, and to proportion condenser size to this area. The condensers may be the single pass type because of the abundant supply of circulating water.

The Hearn 200 Mw. units with double flow exhaust have 37 in. last row turbine blades with a total exhaust annulus area of 183 sq. ft. and a 90,000 sq. ft. single pass divided water box main condenser. The Lakeview 300 Mw. units with quadruple exhaust have 35 in. last row turbine blades with a total exhaust annulus area of 315 sq. ft. and a 125,000 sq. ft. single pass divided water box main condenser. Relative to turbine size these exhaust end sizes are among the largest in operation or under design.

In some cases the manufacturer's experience, or lack of it, with larger blade sizes, will determine the exhaust end size without a complete study; and below the optimum for turbine generator size, fuel cost, capacity factor and range of water temperature. If sufficient design and operating experience has been garnered, the selection of turbine type as influenced by exhaust end size is carried out as an integral part of the overall evaluation, including condenser size and circulating water requirements. For large turbines, exhaust end size variations may result in $1 million or more difference in fuel cost over the life of the plant.

Steam Generator Efficiency— Exit Gas Temperature

Only a portion of the energy supplied to the turbine generator is available energy in the sense that it can be utilized to do work regardless of the degree of perfection achieved in turbine generator design and construction. No similar restriction exists on utilization of energy in the fuel supplied to the steam generator, as substantially all this energy can be released and recovered as heat, provided it is feasible economically to build the requisite apparatus to accomplish the recovery.

It will be increasingly difficult to make great improvements in heat cycle efficiency by increasing turbine inlet steam conditions, even when the present economic limitations on maximum levels of pressure and temperature have been overcome. For example, the gain due to a change in turbine steam conditions from 2350 p.s.i., 1000°F, 1000°F to 4500 p.s.i., 1100°F, 1000°F is less than 5% in heat rate. This fact behooves earnest consideration of reduction in steam generator losses as a means of improving over-all power plant efficiency.

Dry gas and moisture losses constitute the major heat losses from the steam generator; the remaining losses are those due to unburned fuel and radiation. With exit flue gas reduced to the temperature of ambient air, and all water vapour in the flue gas condensed, nearly 100% efficiency of energy conversion can be achieved.

At Hearn, two Lungstrom rotary regenerative air preheaters are furnished of sufficient size to cool exit flue gas to 287°F (uncorrected for leakage) at a maximum steam flow with incoming air at a temperature of 40°F. At Lakeview, the two Ljungstrom air preheaters are furnished of sufficient size to cool exit flue gas to 270°F (uncorrected for leakage) at a maximum steam flow with incoming air at 80°F The corresponding steam generator efficiencies at full load are 88.3% at Hearn and 89.7% at Lakeview. Today's highest steam generator efficiencies are only slightly above 90%.

A further increase in air preheater size will lower exit flue gas temperature and thereby reduce the dry gas loss and improve efficiency. However, operating experience has demonstrated convincingly that the preheater cold end metal temperature must be maintained above the dew point of the flue gas, otherwise corrosion and plugging of the air preheater takes place.

Cold end metal temperature may be considered as the average of inlet air temperature and exit gas temperature, and therefore the higher the inlet air temperature the lower the permissible exit gas temperature. At both plants steam air heaters are provided in the air stream ahead of the air preheater inlet to improve plant efficiency and protect the air preheaters from corrosion and plugging. It may be shown that heating of combustion air above ambient temperature by extraction steam from the turbine is an economically sound method of improving over-all power plant efficiency, and provides a flexible corrosion-protection system for the air preheater.

This improvement is the result of a two-fold gain, (a) an improvement in the thermal cycle due to the generation of additional by-product power, and (b) a decrease in the dry gas loss due to the permissible lower flue gas exit temperature. Approximately 40°F reduction in exit flue gas temperature will raise steam generator efficiency 1%.

At Lakeview, steam air heating will be utilized to raise air preheater inlet temperature to approximately 70°F at full load and 120°F at 10% load for the present fuel. If higher sulphur fuels, such as those available from Nova Scotia, are burned, it will be necessary to heat to 100°F at full load. Although the arrangements are somewhat different, both plants have combustion air intakes within the boiler house, and advantage will be taken of some of the heat dissipated from the boiler casings summer and winter for prewarming combustion air. The inside air intakes also serve as a part of the ventilation systems for both plants.

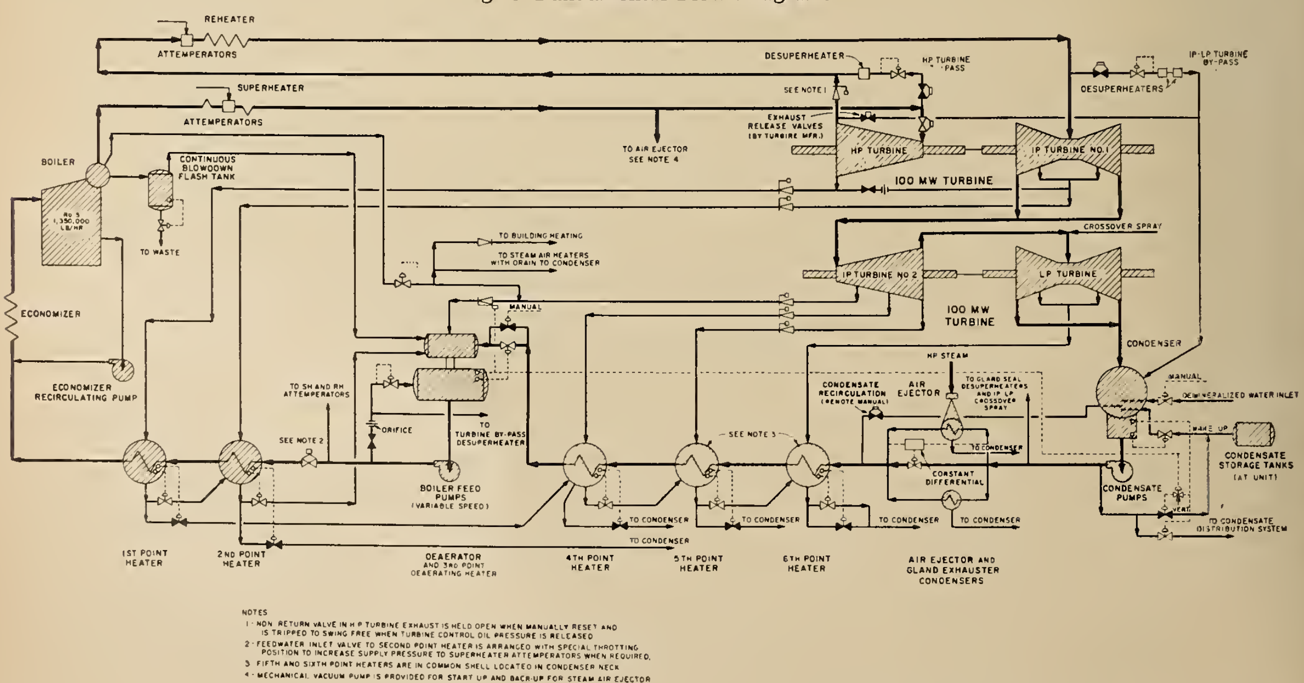
Centralized Control

To fulfil the basic criterion of low operating cost, the necessary operating staff should be kept to a minimum. Centralization of controls is essential, therefore, in order to reduce the number of individual operating duties, particularly in view of the daily stop/start requirements.

At Hearn, the operations of mechanical controls for the four new units are centralized in two control rooms, one for units 5 and 6, and a second for units 7 and 8. Fig. 3 shows the general arrangement of controls for two units. Control of the electrical outputs of the units and associated switching is retained in the original electrical control room, which has been extended to include all the necessary control devices.

At Lakeview, the operations of mechanical and electrical controls for units 1 and 2 are located in a combined mechanical-electrical control room mid-way between the units. Fig.

Fig. 5 Fundamental Flow Diagram.



4 is a mock up of the control arrangement for one unit.

At both plants, all measurements essential for the over-all control and supervision of systems associated with the steam generator-turbine heat cycle are transmitted, either electrically or pneumatically, to the central control room. This arrangement precludes any hazardous fluid in the central control room and allows a much greater concentration of controls and instruments in each panel.

At Hearn, the units can be put into service and operated from the central control room, with the exception of minor local functions which must be performed prior to and during the start-up operations. Among these are the regulating and closing of steam generator vents and drains, turbine drains, and piping drains. Cooling water supplies to pump and fan fluid control drive oil coolers and bearings must be regulated locally. The isolating valves in the steam supply lines to the condenser air ejector and the turbine gland steam system, must also be operated locally.

At Lakeview, additional provisions are incorporated to regulate steam generator vents and drains, turbine and piping drains, and condenser air ejector and turbine gland steam system from the central control room on start-up. This is done by providing either air-diaphragm or electric-motor-operated valves for these services. Cooling water controls for fluid control drives serving major auxiliaries are automatic, normally not requiring operator attention. Lakeview is one of the first, if not the first, large thermal station to be designed for remote start-up to this extent.

For both plants the major control systems, such as combustion control, feed water control, and steam temperature control, are automatic, normally requiring only surveillance and monitoring by the operating staff for abnormal deviations. Under start-up conditions these systems are manually operated from the central control room. Also, for both plants, there are other control systems for major ancillary equipment which are completely automatic, even under start-up conditions. These include minimum flow control for the boiler feed pumps, air ejector and gland condenser, extraction feed water heater drainage level control, and condenser, deaerator and water storage tank level control. Some are brought to the control room in order to apply manual corrections under adverse operating conditions, others are monitored in the control room only for extreme deviations.

Operating cost and capital investment can be reduced by eliminating equipment intended for local operation, such as hand-operated by-passes and shutoff valves. At both plants the conventional hand-operated by-passes have been replaced by electric or diaphragm motor valves on the main boiler feed system, feed water heater drainage system, and deaerator and condenser level control systems. This reduces the amount of operator attention required, particularly during emergency conditions. At Lakeview, initial costs have been reduced on the condensate, heater drainage, and other systems provided with automatic or control-room-operated by-passes, by eliminating many of the shut-off valves normally provided for isolation of control valves. This has been done on the basis that if the primary control fails, bypass control is available, and maintenance can be deferred until an overnight, week-end, or longer shutdown.

This may appear to be a minor item, but consider that approximately $50,000 per unit can be saved for elimination of isolating valves, due to savings in first cost of valves and piping, access platforms, and design cost. On the basis of a turbine generator unit installed each year, this saving can be considered an annual one, and at the current long-term interest rate, would have a present worth in excess of $1 million.

Steam By-Pass System

Perhaps the most unusual, if not unique requirement for large thermal units is the daily start/stop operating condition. To minimize fuel and over-all system power costs it is desirable to reduce the time of the start-up as much as possible, so that only a minimum of thermal generation has to be absorbed by the system, while the capability of hydro-generated power is still in excess of the system demand. The deleterious effects of rapid starting will be least if temperature change in the turbine, and temperature differential between steam supply and the turbine, can be minimized.

At the Hearn Station a high and low pressure turbine steam by-pass system is provided to facilitate the rapid start-up of the turbine generator after an overnight shutdown. The by-pass system will provide hot steam for admission to the high pressure and reheat turbines respectively, and by minimizing development of thermal stresses in the turbine parts, will increase availability and decrease maintenance.

The system consists of a large steam by-pass line from upstream of the high pressure turbine inlet connecting to the cold reheat line, and another large steam line from the hot reheat line to the condenser. Motor operated isolating valves, pressure reducing valves, desuperheating stations and instruments are provided. The fundamental flow diagram for Hearn Station, Fig. 5, shows the major connections for this system. By means of this by-pass, sufficient steam flow (10% to 15% of maximum flow) can be passed from steam generator to condenser to raise superheater and reheater steam temperatures to those required for admission to the turbine.

By suitable unloading procedure, operation of the turbine each day at steam temperatures below the normal 1000°F, at both the high pressure and reheat turbine inlets, can be minimized, thus alleviating repetitive heating and cooling of critical high temperature turbine parts. At the beginning of the shutdown period it is anticipated that the turbine metal temperatures will be almost the same as during normal full load operation, and with the turbine bottled up overnight, it is expected that critical parts will cool only moderately. Temperature recorders are provided to measure the turbine metal temperatures at critical points throughout the unit.

A similar by-pass system has been designed for Lakeview. Installation awaits completion of operating tests on the Hearn System.

Structures

At Hearn, the original completely-enclosed brick station structure was extended to conform to the original station layout as much as possible, and to retain consistent appearance. However, the upper portion of the boiler house and coal and ash handling structures added with the extension have been built with less expensive aluminum siding. At Lakeview aluminum siding is used for the main station structure, although a small amount of brick is used at ground level because of its greater durability and for transformer fire protection. Induced draft fans, hot air ducts, and precipitators are out-of-doors at Lakeview, thereby not only reducing structural costs, but also ventilation requirements.

Investment in large maintenance facilities and shops at Lakeview has been deferred, at least until more units are installed in the station, with the expectation that major repair work can be done at Hearn or elsewhere. Similarly, at Lakeview no substantial investment has been committed for future units, other than the minimum necessary to ensure relatively complete flexibility of design. EIC

Discussion

PROCESSING OF LOW-GRADE IRON ORE USING PETROLEUM AND NATURAL GAS

P. E. Cavanagh,
Vice-President, Premium Iron Ores Limited, Montreal.
The Engineering Journal, August 1959, p. 84

Discussion by William B. Magyar, Jr.E.I.C.

While the article by Mr. Cavanagh was most interesting and timely . . . there are a number of controversial points which require clarification.

For example, the bases for comparison for the processes are questionable and the conclusions drawn by the author are open to considerable discussion and debate. In addition, the article contains a number of technical errors and omissions, especially with regard to the author's interpretations of the Strategic-Udy process.

The recirculated furnace gases are utilized for their heat of combustion and not for prereduction.

No arbitrary figure can be selected as the ideal for maximum prereduction as this factor depends on the characteristics of the ore itself. A free-flowing kiln discharge product (frequently called a sinter) is desired for feeding the electric furnaces. Consequently, the maximum degree of prereduction desired for a particular ore or concentrate must be determined by experimenting.

Mr. Cavanagh's statement that "the maximum degree of prereduction that will prove feasible is about 30% on a rich ore" is true, we agree, for conventional electric furnace smelting, but not for the Strategic-Udy technique.

For example, the following results have been obtained:

A 65% prereduction in the kiln on a normal, direct-shipping, blast furnace type ore containing 56% Fe. No difficulties were encountered in subsequent furnace operations;

Over 70% prereduction has been attained on lean "contaminated" concentrates from a Canadian ore;

Stainless steel grindings — almost 100% metallic — were smelted at SUMAC on a production scale, cast into ingots and returned to the supplier as melting stock. The grindings were cold-charged directly into the electric furnace.

Electric power consumption has been measured accurately on many ore or concentrates at SUMAC via large-scale smelting tests. The smelting of 65% Fe pellets has not yet been demonstrated, but preliminary calculations suggest about 900 kwh. per ton of semi-steel would be required for such material.

No information from Strategic-Materials Corporation was found which indicated a consumption of 1400 kwh. per ton of iron from such material as stated by Mr. Cavanagh.

There is a tendency among metallurgists to compare estimated production costs via these new processes with established blast furnace costs in various steelmaking centres. This type of comparison, unfortunately, does not reflect a true picture.

For a proper evaluation of a new situation one must compare the total costs via the blast furnace route—including coke ovens, sintering, etc. —with total costs via the direct reduction route at the proposed location of the new enterprise.

Consequently, fuel costs will not be the only criterion as suggested by Mr. Cavanagh. Each of the four cost items mentioned in the article become important when local conditions are taken into consideration.

These items were: iron ore required; fuel and power costs; capital charges, depreciation, etc.; and the cost of all other materials, labour, supervision, repairs and maintenance.

It is incorrect to think of direct reduction as an immediate means of replacing currently installed blast furnaces. Most of the blast furnaces are maintained in good condition regardless of their age. They have been paid for many times—on the books.

They are producing pig iron at an enormous rate and they represent gigantic investments.

As a result they will require tremendous tonnages of high grade ores and concentrates for many more years. No efforts will be spared to improve the output of blast furnaces and their ore requirements will be met until the plants become obsolete.

Where the Strategic-Udy plants should be considered are in new-grass root installations and at auxiliaries to consume fine iron-containing materials generated in the blast furnace and ore preparation plants.

Discussion by F.M. Senior

While parts of Mr. P. E. Cavanagh's article, "Processing of Low-grade Iron Ore Using Petroleum and Natural Gas", were well conceived, the discussion of the Strategic-Udy Process in particular is presented in a manner that indicates an incomplete understanding of the metallurgical and thermodynamic factors.

The recent large scale developments of Strategic-Udy have demonstrated a large degree of acceptance by both leading steel producers and some of the world's outstanding iron and ferroalloy metallurgical engineering groups. Both Koppers Co., of Pittsburgh, and Elektrokemisk A/S, of Norway, are joined with Strategic in the development of the process.

It should be borne in mind that Strategic-Udy, (together with Koppers and Elektrokemisk), is currently fabricating equipment for the progressive installation of Strategic at the world's largest electric steel plant, (1,200,000 tons per year with nine 33,000 kva. furnaces), at Matanzas, Puerto Ordaz in Venezuela. Currently Strategic, in a joint venture with The Universal Cyclops Steel Corp. of Bridgeville, is installing a 10,000 kva. furnace and large kiln at SUMAC, the Strategic Plant at

(Continued on page 170)

Automation and Control Engineering in Canada

Economic Aspects of Instrumentation

J. Van Damme, M.E.I.C.
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IN THE very early stages of any engineering project the question of cost becomes and remains the dominant factor. In industry in particular, the simplest and cheapest design is always the best, and the sole justification for a new piece of equipment is its ability to produce the highest quality goods or services at the lowest price. By keeping this in mind as we approach the intricate and involved technology of modern automatic control systems, the mystery of instrumentation can be by-passed and instruments can be treated just like any other piece of equipment.

The first step is to weigh the cost of the equipment against the benefits to be derived. The evaluation of the benefits is a lengthy business, closely tied to the economics of the process itself. The cost of a control system is made up, not only of the purchase price of the various elements, but also the installation costs and the commitments for the future such as maintenance, operator training, etc.

In its simplest form a control system is a series of components feeding signals from one to another within a closed loop for the purpose of maintaining a given variable at a certain value. All control loops are divided into three main parts, namely a measuring section, a control section and the process or machine elements themselves.

The measuring apparatus is based on some physical or chemical property of the variable in question, such as the movement of a bourdon tube for pressure or the expansion of mercury for temperature. Measurements may be blind, (no reading of any sort), indicating (a pointer moving against a scale), or recording (an inked record on a chart). A variable may be measured in one location and transmitted to another by converting it to an air pressure or electrical signal in what is called a transmitter. The receiver is the device that converts the signal at a remote point into a reading in terms of the original variable (indicating or recording).

The control section is composed of the group of devices which correct the variable to the desired value. These pieces of apparatus are common to all variables and range in complexity according to the accuracy desired and the ease with which the correction can be made. A simple room thermostat in a house is an on-off control working between an upper and lower limit. A simple throttle governor with valve is a proportional control which increases flow under increased load as it takes up a new control point at reduced speed and vice versa. Reset and derivative actions are refinements which come into the picture as a control problem becomes more involved. Complex systems in which several instruments and loops interact with one another are quite common.

A good way to evaluate the benefits that will result from the installation of a control system is to consider the advantages separately under the following headings:

1. Increase in output
2. Improved yield
3. Waste reduction
4. Greater utilization of labour force
5. Improved quality
6. Reduced services
7. Prolonged equipment life
8. Reduced maintenance
9. Reduced down time
10. Replacement of more expensive equipment in new design
11. Achievement of a process or a result otherwise unobtainable.

You will find that only a few of these pay off in any specific application. Some typical examples will serve as illustrations.

A continuous fabric dryer had been used for years at speeds considerably below maximum. All attemps to speed it up failed because of degraded fabric. A moisture controller immediately produced a 20% increase in output with improved quality. Paper machines are benefitting greatly from similar devices. The yield in steel mills has been increased considerably by using instruments to control the dimensions of plate and sheet to tolerances undreamed of 20 years ago.

The most striking examples of all can be found in the reduction of waste. Two air compressors were running continuously to satisfy plant demand. An automatic stop and start on one of them cut the power bill by 10%. Increased production in a certain plant created a water shortage. Before spending $100,000 on extra pumping and clarifying equipment, flow meters were installed in 14 branch lines at a cost of $12,000. By merely confronting each department with a record of its consumption, the total flow went down by 900 gpm. for an annual saving of $15,000 and the proposed extension was postponed indefinitely.

A series of dye jigs transferring fabric back and forth between two rolls had to be reversed by the operators as the fabric ran out. By installing counters on the rolls the jigs were made to reverse automatically. The saving per jig was well over $1000 a year for $200 expenditure.

Instruments can be of great value in new design. For example, $10.000 was saved in a duplicate dilution system for sulphuric acid by replacing vats and tanks with an automatic blending system using flow and conductivity controllers.

Modern oil refineries and chemical processes could not exist without their complex of automatic controls. Many machines or processes found impractical in previous years can now be developed through the use of instruments. The economic advantage is sometimes hard to find because it is several times removed from the controlled variable, but what finally counts is the profit on the final goods.

It requires imagination to take full advantage of an automatic device. One gas station operator using a newly installed automatic shut-off valve on the filling hoses of his gas pumps didn't think much of it. His competitor across the street found business up 25% after installing the same device because he could speed up service by cleaning the windshield while the tank was filling.

The man best situated to evaluate the benefits to be derived from instruments is the process or machine supervisor. If he can team up with an engineer familiar with the instrumentation field, the pair, working together, can produce amazing results.

In estimating the cost of instrument installations, reference may be made to Table I. Figures from this table are accurate enough for preliminary estimates, to be corrected as the design advances. The table will also serve as a basis for individual lists modified to suit local conditions and future developments.

In analysing the cost of a control system, purchase price and installation are not the only factors. Although automatic controls are very reliable they do require some attention from time to time, and thought should be given in the early stages to the means of servicing them. This may be an expensive item. However, an instrument maintenance crew is inevitable in all but the smallest firms since more equipment is being produced every day already fitted with pneumatic controls, and the sooner a firm trains personnel to service them, the sooner it will adapt to modern methods. In large cities the maintenance can be bought from companies specializing in this field.

If a firm decides to build up its own maintenance crew, certain fundamentals should be accepted at the very beginning. Instrumentation is a new field with its own character. It cannot function as an appendage to an electrical or plumbing shop and it has no place in an operational group. Even if there is only one instrument man in the whole organization, he should be a separate entity reporting directly to the senior engineering supervisor and he must be left free to do all types of work on the instruments, whether it be electrical, mechanical, pneumatic, hydraulic or chemical. There is a shortage of skilled instrument repairmen today so the employer must be prepared to pay a premium and train them. The majority of the instrument men must have high technical qualifications (senior matric). Even a slight deviation from these principles will result in costly errors.

The application of automatic controls to established processes will inevitably cause repercussions which can be dealt with more economically if they are foreseen in the original plans. Labour unions have been known to expect workmen to be kept on doing nothing when automation has eliminated their work. The unions may also object to the status of the instrument mechanic whose work classification does not fall into the old AF of L trade categories. Then again, the operators who use the instruments must be trained, since new concepts are involved. The fact that the pen and the index of a proportional controller are seldom together is rarely accepted or appreciated even

TABLE I
Instrument Costs (dollars)

Commercial Controls

Room thermostat, electric on-off	10	Valves, ½ in. radiator	25
Room thermostat, pneumatic master	40	¾ in. radiator	40
Duct thermostat, pneumatic submaster	70	Humidistat	80-100
Dampers with motor	5 to 15 per sq. ft.	Manometers	5-10
		Thermometers	1-2
Industrial Instruments			
Indicators			
Manometers	50-200	voltmeter	300-400
Pressure gauges, air, water	4-50	Potentiometer, galvanometer	150-300
special applications	50-300	Rotameters, air purge	25
Thermometers	8-50	¼ in.	25-75
Flow totalizer, depends on size	100-300	1 in.	50-125
Speed, generator and indicating		3 in.	200-400
Single Case Recorders			
Pressure, 3 to 15 psi air	180	pH	800-1200
other, will depend on element	200-500	Moisture membrane	200
Temperature, pyrometer	200	dew point recorder and special	1000
vapor pressure	250-300	Level	350-450
liquid filled	300-500	Viscosity	500-1000
Flow, manometer	400-700	CO_2	500-1000
orifice plates, nozzles for above	50-200	O_2	1000
special applications up to	2500	Sampling systems for above	300
Conductivity not compensated	800-1000	Smoke recorders	1200
temperature compensation add	200	Self-balancing potentiometers	800-1000
Controllers to Fit in Above Recorders			
On-off	100-250	Proportional and reset and derivative	600-700
Proportional	425-500	Pneumatic-set add	200
Proportional and reset	550-600		
Transmitters — Receivers			
Receiving recorder, pneumatic, 1 variable	180-250	Temperature	250-350
2 variables	300-325	Differential pressure, water	200-250
3 variables	380-410	high pressure and special	300-500
EMF recorder	600-1000	Level	150
Pressure transmitter (depends on element)	200-500	Speed pneumatic	325-420
		electric	200
Remote Controllers for Above			
On-off and special purpose relays, pneumatic	40-150	Proportional and reset	180
Proportional	150	Proportional and reset and derivative	245
Control Valves			
½ in. globe type, water	90-100	4 in. globe type, water	425
1 in. globe type, water	175	5 in. globe type, water	500
2 in. globe type, water	250	6 in. globe type, water	575
3 in. globe type, water	350		

For linear and percentage plugs add 10% to 20%.
Special materials are extra, for example a 6 in. reducing valve for 600 lb. steam costs $2500.

Special			
Static pressure blind controller	100	Six pen recorder add	350
Integrator	100-225	Conductivity electrodes	25-100
Positioner	100-150	pH electrodes	35-150
Accessories			
Polyethylene tubing ¼ in. OD	2½c/ft.	and 4-way	$40 to $50
Copper tubing ¼ in. OD	7c/ft.	Timers	$25 to $75
Tube fittings, each	25c to 75c	3-way air switching valves	$25
Switches, pneumatic, 3-way			

Installation Costs

These vary tremendously with the complexity of the installation and to some extent with wage rates. Basic installation costs of simple temperature and pressure controls is $50 to $100. Flange mounting level transmitters cost $50. Other instruments will range in the same order. Installation costs go up rapidly with specials or unusual conditions. Add extra for
Centralized panels
Extra long runs
Remote power or air supplies
Corrosive conditions
High pressure or temperature
Hazardous atmosphere
Freezing temperature
Engineering services
Start-up services
Delays from process in use

Use a check list to make sure the following extras are not overlooked
Switches
Orifice flanges
Purge systems
Seals
Electrical or air supplies
Gauges
Thermometers
Pilot lights
Alarms
Special wire
Timers
Conductivity and pH cells
Sampling lines
Dessicators

Control valve installations usually require a gate valve upstream and downstream of the control valve with a globe by-pass. Allow the price of the control valve for buying these and installing the valve system.

If the instrument company recommends sending an engineer for installation or start-up, buy the service but base your specifications on results, not equipment.

by senior supervisors.

Measuring instruments are available for most known variables. Besides the common ones, one could mention conductivity, speed, moisture, pH, mass, position, radox potential, acidity, alkilinity, concentrations of substances such as CO_2 and O_2, acetic acid, colour, water hardness and many others. Instrument manufacturers are eager to investigate new fields provided that the expense is justified by sufficient volume of future business.

Most variables can be measured in many different ways, e.g., a flow meter could be a variable area device such as a rotameter, a fixed orifice such as a venturi tube with a differential pressure recorder, an impeller or propeller type totalizer, a volumetric meter such as the gasoline pump at the service station, a hot-wire anemometer for air flow measurement, or a magnetic flow meter.

There are many designs and many manufacturers to choose from. All the major instrument companies are reliable and can be depended on to provide a successful installation; in fact they take such pride in producing results that it is not unusual to find a company refusing to sell an instrument because there is some doubt about it being suitable for the job. The uninitiated engineer can safely rely on the advice of any one of the major instrument companies.

In buying instruments it is wise to obtain proposals from several companies, but the emphasis should be placed on finding the simplest instrument best suited for the job. Dependability, performance, ease of installation and suitability for the application are far more vital than a small difference in purchase price.

Wherever possible, instruments should be chosen from those manufacturers who are well experienced in the field. For instance, one manufacturer specializes in boiler controls, designing them to meet the needs of the boilers. What is standard equipment for him would be special for another firm. This same manufacturer has serious limitations in other fields. A good knowledge of the products and services of each instrument company is essential if the equipment is to be used to the best advantage.

At the close of World War II the instrument field grew very rapidly around the pneumatic controller. These instruments now form the backbone of the automatic control world of the chemical and oil industries. More recently, with the development of the transistor and the magnetic amplifier, a group of instruments has grown up which are generally classed as electronic controllers. The engineer may be faced with the problem of deciding which to use. Generally speaking, the electronic controllers are more expensive than the pneumatic by 10 to 30% and require auxiliary power at the control valves. The electronic controller has the advantage of faster response and many users claim that it will stand up better in tropical climates. Whatever the pros and cons, pneumatic controls are far in front of electronic in both variety and quantity.

Ten years ago, all parts of an instrument were contained in a single case. Today almost any known variable can be transmitted over long distances as an air pressure or an electrical voltage or current, and controls located at the site of the process can be regulated from a remote control room. On small installations the designer is faced with a choice between the integral controller and the remote transmitter type. On the average, the latter costs $100 to $150 more. Where the instrument is bought for a specific application and will never be moved or altered, the single case controller is usually used. Where the possibility exists of altering the requirements of the control system or moving the machine or modernizing the machine or process, or where trials and experimental work are involved, the flexibility of the transmitter type control system makes it well worth the few extra dollars. Most transmitters are built with a range span which can be raised or lowered at will. This gives an accuracy, range and flexibility which can never be achieved in a single case controller. Pneumatic transmitters have a standard output at 3 to 15 p.s.i. making the controllers interchangeable so that servicing becomes a simple matter of replacing a plug-in section. The advantages of the remote transmitter control systems should not be overlooked.

Another alternative facing the designer is whether to make the system indicating or recording. Generally speaking, if a variable is worth controlling, it is also worth recording. There are exceptions, such as comfort cooling controls or storage tank levels. Where an off standard condition costs money, the record is essential. On industrial instruments the recorder costs only $75 more than the indicator and 100 charts can be bought for $2 to $3. Two types of charts are commonly used, the circular 10 in. or 12 in. diameter, and the strip chart 4 in. wide running at 18 in. to 24 in. a day. There is little to choose between them. The circular chart gives a poor time record when the pen is near the hub, but it is stiffer and easier to handle when half a dozen charts are being compared. The man operating the process should change his own charts.

A word should be said about the difference between industrial controls and analytical instruments since they must be treated differently. It is easy and dangerous to confuse the two. The economic advantages of the analytical instruments can only be evaluated by the chemist or physicist associated with the lab requiring them. Maintenance can usually be bought from the supplier and installation usually consists simply of providing a power outlet. Automatic process controls require a completely different approach. An engineering analysis of process lags and capacities and their interaction upon one another is essential. Specification of components will depend on the analysis. Installation techniques can be extremely involved. Familiarity with analytical instruments does not make one an expert in process control or vice versa.

Automatic control systems are not omnipotent. They cannot correct for a change which has not occurred. In other words, they can only bring back a variable to its control point after it has left that point. If, as a result of poor design, this deviation is large, the instrument cannot provide close control. Much expense and redesign can be eliminated by giving thought to process capacities and process lags in the initial stages. For example, a common mistake is to try to get close temperature control from a heat exchanger by placing a control valve at the steam inlet. The exchanger will continue heating long after the steam has been shut off. A bypass and mixing valve should be used and, if necessary, some storage and mixing at the outlet.

Every September the Instrument Society of America holds an instrument show in one of the major American cities. Engineers associated with process development or machine automation are advised to attend.

There is greater progress to-day in the design and development of instruments than in their application and many engineers are unaware of the full value of these tools. Automatic controls developed for a certain industry can benefit many other industries. To keep abreast, the plant and process engineer must scan the field regularly and reanalyze his processes for ways of reducing costs by taking advantage of instrumentation. EIC

Canadian Developments

Small Reactors For Northern Canada

Studies of small United States reactor types that use enriched uranium for fuel have resulted in a report concerning small nuclear power plants in northern Canada. Operating cost of these small reactors was compared with the estimated cost of an oil-fuelled electricity and heating plant proposed for Frobisher Bay on Baffin Island.

The report, prepared for Atomic Energy of Canada Limited, said the annual operating cost of a small nuclear power plant at Frobisher Bay would be 22% greater than the annual cost of operating a conventional oil-burning power plant there. The plants compared would each produce 2,000 kw. of electricity and 17,500 kw. of heat for a population of 1,500.

Another conclusion was that if there were an Arctic centre that required a nuclear plant large enough to produce 4,100 kw. of electricity and 35,900 kw. of heat, then the annual cost of a nuclear plant would be only 2% greater than the conventional, oil-burning plant.

The natural uranium fuelled and heavy water moderated plant such as that built at Douglas Point, Ont., has a low fuel cost but a high capital cost. Because of the capital cost, this type of station will be economic only if it has a relatively large power output, in the region of 150,000 kw. or more. Thus it would be unsuitable for Arctic centres that require small amounts of power and space heating.

Because of this, studies were made of United States reactor types that use enriched uranium for fuel and ordinary water for coolant. Known as pressurized water reactors and boiling water reactors, they have higher fuel costs because they use enriched uranium for fuel, but have lower capital costs because they can be made in smaller sizes.

Unknown River Being Harnessed

Work has begun to harness the troubled waters of the Unknown River in Labrador's hinterland.

In its annual report the British Newfoundland Corporation Limited said construction has started of a 120,000 hp. hydro-electric plant at Twins Falls on the Unknown River, a tributary of the Hamilton.

About $30 million will be spent on the project, and provisions are being made for an increase in output when contracts for available electricity are obtained. Twin Falls is about 240 miles north of Seven Islands, Que.

Initially the power will be transmitted west 110 miles to the new iron mines of the Iron Ore Company of Canada and Wabush Iron Company, Limited. These two companies will participate in the ownership of the Twin Falls project.

The company's primary goal is the harnessing of the 4 million to 6 million hp. potential on the Hamilton River. At Twin Falls, where the estimated potential is 300,000 hp., the company can satisfy smaller power requirements at the same time it is pushing ahead with long-range plans.

Of the Twin Falls potential, development of 120,000 hp. in the first stage will be accomplished by installing two 60,000 hp. units.

The Iron Ore Company and Wabush Iron Company have agreed to take a total of 100,000 hp. of delivered power at Wabush Lake. The balance of the generated power, less line loss, will be available at the Wabush Lake town site. It is expected that the Iron Ore Company will take the first power June 1, 1962.

Frogmen Help Maintain Montreal's Sewer System

One thousand miles of sewer mains accommodate the water needs of Montreal's citizens. This maze also presents the city's Public Works Department with a difficult maintenance problem.

At times the city calls on a firm specializing in underwater work which sends its frogmen deep into the aqueduct and sewer systems.

Problems vary from season to season, and from sewer to sewer. Frazil ice, clogged grilles and jammed gates all can be dealt with effectively once first-hand information has been obtained.

One difficulty was encountered in sewers built in recent years. Deposits of fatty matter and oil forming a gel-like substance had reduced the openings of the main from 12 ft. to 3 ft. In these areas frogmen had to work in thick mud which made their progress extremely difficult.

Boundary Dam Planned as Water Conservation Project

The Boundary Dam on Long Creek at Estevan, Sask., was planned by the Prairie Farm Rehabilitation Administration as a water conservation project.

Subsequently it was built as a reservoir to provide cooling water for the Boundary Dam generating station.

One of the principal activities of the P.F.R.A., a branch of the federal Department of Agriculture, is the construction of water conservation and irrigation projects, of which the South Saskatchewan River Dam is one.

Because the P.F.R.A. carried out the original plan for the Boundary Dam, and because it had the experienced staff the Saskatchewan Power Corporation negotiated with the federal government for the Administration's engineering services for the construction design.

Controlled Explosions Clear Shipping Menace

A sunken freighter lying on her side in 50 feet of water east of Montreal's Jacques Cartier Bridge is being carved to pieces by carefully-controlled underwater explosions.

Following a collision last spring the Federal Express sank 800 feet from shore in the St. Mary's current. Divers are removing this hulk with explosive charges.

Shock waves, which possibly could damage dock installations, are cushioned by a curtain of compressed air bubbles which rise from a perforated pipe placed between the blast and the shore.

A 300-foot steel deflector anchored upstream from the operation enables the divers to place their charges in the swift current.

The four-month project is scheduled to be finished before freeze-up.

University of Waterloo Adds Five Companies to Advisory Council

Five companies have been voted membership in University of Waterloo's Industrial Advisory Council. The Council is composed of representatives of about 30 companies and meets twice a year at the university. It advises on matters of student programing and training relating to the students' industrial assignments which are an integral part of Waterloo's co-operative engineering course. Students in the course alternate attending classes and working in industry every three months. EIC

International News

Contracts Awarded for Cross-Channel Power Link

A power link joining Britain and France has come one step closer with the signing of a £610,000 contract for power cables by the Central Electricity Generating Board.

Awarded the British contracts were Associated Electrical Industries Limited and British Insulated Callender's Cables Limited.

These two cable-making firms will place half the submarine cable link which will connect the national electricity systems of Britain and France. The cables are scheduled to be placed next summer.

Patterns of electric consumption vary greatly between the countries due to difference in climate, clock times, hours of work and habits. These differences in demand upon the two networks result in the availability of some hundreds of megawatts at peak winter loads.

As planned, the connection will transfer 160 Mw. at peak periods, and will transfer power at other times to meet conditions such as surplus or shortage of water at hydro stations.

The ability of the countries to call on one another for extra generating capacity eliminates the need for extra plants and will work to their mutual economic advantage.

The contract calls for the manufacture and placing of two similar 15-mile lengths of single-core submarine cable and two related land cables. The work is to be divided equally between the companies.

The connection between the British 275,000 v. Supergrid and the 225,000 v. French network will be by direct current circuit of 160,000 kw., with a 20% overload for isolated periods of 30 minutes. The direct current transmission will operate at 200,000 v. between poles, with its centre point earthed, and the cables will be insulated for a nominal voltage of 100,000 v. to earth.

Normal full load current will be 800-amp. When completed, this submarine circuit will carry the heaviest d-c. load ever transmitted under water.

The cables themselves, as developed successfully from sea trials, are of the impregnated-paper insulated solid type. The submarine cable conductor cross section is .525 sq. in., and consists of stranded copper wire lapped with an electrostatic screen. The solid type impregnated paper insulation, also lapped externally with an electrostatic screen, is sheathed with lead alloy "E" which is protected against corrosion by vulcanized rubber tapes.

Armouring is provided by a single layer of .232 in. galvanized steel wires with appropriate beddings and servings. The cables weigh about 39 lb. per yd. in air and about 28 lb. per yd. in sea water.

Swedish Firm Lands Large Transformer Order From United States Government

The Swedish Asea Company, competing with American, Canadian and other European firms, has been awarded a $1 million order for 10 transformers from the United States Government, represented by the U.S. Army Corps of Engineers.

Ordered were one 103,000 kva. three-phase transformer for 115 kv. and nine 68,700 kva. single-phase transformers for 230 kva.

The transformers are intended for a large hydro-electric power station at the Oahe Dam on the Missouri River in South Dakota. Shipments of the first units are to start in mid 1961 and delivery is to be finished a year later.

Russian Scientific Papers Available in English

Translations of important Russian books and articles of scientific interest have been made available through the Program for Scientific Translations in Israel.

Material which has been translated into English was selected in accordance with the requirements of the National Science Foundation, Washington, which initiated and supports the program.

The Foundation has entrusted the Program with sole distribution outside the United States of all translations listed. The 1960 catalogue lists 22 broad categories and can be obtained from: Program for Scientific Translations, P.O. Box 7145, Jerusalem, Israel.

Metropolitan Sydney To Have New Concrete Bridge

A Melbourne company which recently completed a 2,074 ft. prestressed concrete bridge has been awarded the tender to build a smaller bridge in metropolitan Sydney.

John Holland (Constructions) Pty., Limited will build a 657 ft. five-span bridge of prestressed and reinforced concrete over the Parramatta River at Silverwater. The company's bid was £460,000. The bridge will have a pair of two-car lanes separated by a median strip, and two pedestrian walks.

El Salvador Gets World Bank Loan For Expansion of Electric Power Facilities

El Salvador, the smallest and most densely-populated of the Central American republics, has been given a loan equivalent to $3,840,000 by the World Bank for expansion of electric power facilities.

The loan will finance imported equipment and services for the construction of the Guajoyo 15,000 kw. hydro-electric power plant and associated transmission facilities.

Receiving the loan was the Comision Ejecutiva Hidroelctrica del Rio Lempa, a semi-autonomous government agency established in 1945 to plan and provide facilities to meet El Salvador's power requirements. It supplies power wholesale to the country's principal distributors of electricity which serve nearly all consumers.

Canada-India Reactor In Operation

The Canada-India Reactor went into operation July 10 at Trombay, India, it has been announced by India's Atomic Energy Commission and Atomic Energy of Canada Limited.

The research and engineering test reactor, a modified version of the NRX reactor at Chalk River, Ont., is the result of five years of close co-operation between engineers, scientists and technicians of the two countries.

The reactor was built through the Colombo Plan as a joint Canada-India project. Canada's share of the cost, which covers the reactor, the start-up and the training of Indian personnel, is about $9 million.

CIR is expected to operate at its full output of 40,000 kw. of heat on a routine basis beginning this autumn. EIC

Month to Month

100 Years Ago

A group of men gathered together on October 10, 1860 for the first meeting of The Association of Provincial Land Surveyors and Institute of Civil Engineers of Canada. The Association, believed the first engineering organization in Canada, had been incorporated under the laws of Upper Canada. Seventeen years later the Canadian Society of Civil Engineers was formed, and by Dominion Act of April 15, 1918, its title was changed to The Engineering Institute of Canada. This change of title indicates the broad general character of the Institute.

Requirements Survey for Professional Personnel

An increased demand for engineers and scientists during the next two years is forecast by the Economics and Research Branch of the Department of Labor. In its 1960 biennial survey of requirement for professional personnel in scientific and technical fields the branch received information in industry, government and education from employers of about 27,200 engineers, 12,500 scientists and about 600 architects.

By 1962 it is estimated 5.5% more engineers will be required. This ranges between a 6.8% increase in demand for metallurgical engineers to 1.4% increase in demand for geological engineers. The average increase in demand for all scientists is 4.6% with the range between 9.3% for mathematicians and 2.6% for agriculture scientists. The anticipated increase in demand for architects is 6.6%.

Institute Represented at Buenos Aires

The Institute had strong representation at the Sixth Congress of the Union Panamericana de Asociaciones de Ingeieros at Buenos Aires, Argentina, September 18-22.

Twenty-one Members from Canada, the United States, Argentina and Uruguay served as delegates or alternate delegates to the Congress. In addition to representing the Institute at the UPADI Congress, Dean H. G. Conn of Queen's University's Engineering Faculty and Dean R. R. McLaughlin of the Faculty of Applied Science and Engineering, University of Toronto, also attended the First Pan American Congress on Engineering Education in Buenos Aires, September 12-17.

Head of the Institute delegation and representing President George McK. Dick, was Dr. James A. Vance of Woodstock, Ont., a Past President. Another Past President, Dr. K. F. Tupper of Toronto, was deputy head of the delegation and President's representative.

Fifteen Institute representatives also formed a Canadian Mission of Consulting Engineers which travelled to other South American countries to promote closer relations between Canadian and Latin American members of the profession.

Following the UPADI Congress the Mission went to Santiago, Chile; Lima, Peru and Bogota, Colombia.

Gordon Churchill, Minister of Trade and Commerce, said Canada's consulting engineers are particularly well equipped to understand Latin American conditions and requirements because in the large-scale development of natural resources in Canada they have solved similar problems.

Objectives of the Mission were to acquaint Canadian consulting engineers with Latin American opportunities; to draw attention of Latin Americans to the availability of Canadian engineering through consulting engineers; to assist those newly interested in export markets to determine for themselves the opportunities in Latin America and the advisability of becoming active there; and to assist those already established to renew existing contacts and to make new ones.

The Department of Trade and Commerce will be represented on the Mission by Chief of the Engineering and Equipment Division, R. A. Frigon, who will act as secretary. Spokesman for the Mission is Charles C. Huston of C. C. Huston and Associates, Toronto.

Besides Dean Conn, Dean McLaughlin, Dr. Vance and Dr. Tupper, the Institute delegates to the UPADI Congress were: Leo Scharry, Honorary Vice-President, E.I.C., Sangamo International Inc., New York City; C. R. Vegh Garzon, Honorary Vice-President, E.I.C., Montevideo, Uruguay; Mr. Frigon, also an Honorary Vice-President, E.I.C.; Professor Carson Morrison, Honorary Vice-President, E.I.C., of Morrison, Hershfield, Millman and Huggins, Toronto; G. R. Adams, Manager, Overseas Operations, Foundation of Canada Engineering Corporation Ltd., Montreal; C. A. Dagenais of Surveyor, Nenniger and Chenevert, Montreal; Frank Athey, Buenos Aires; and W. H. Beaton of Beauchemin, Beaton and Lapointe, Montreal.

Alternate delegates were: N. Fodor of Nicholas Fodor and Associates Limited, Toronto; Paul Pelletier, President of Paul Pelletier Engineering Limited, Montreal; W. N. Papove, General Manager of Pathfinder Engineering Limited, Vancouver; G. G. Hatch, President of W. S. Atkins and Associates Limited, Toronto; Mr. Huston; R. M. P. Hamilton, President of General Engineering Company Limited, Toronto; Harold Wright, President of Wright Engineers Limited, Vancouver; A. T. Hurter, President of Stadler, Hurter and Company, Montreal; and H. B. Tafelmacher, Montevideo.

Among the Institute delegates to the Sixth UPADI Congress in Buenos Aires were, from the left: Dean H. G. Conn, Dean R. R. McLaughlin, Dr. James A. Vance and Dr. K. F. Tupper.

Coal Research Conference

"Institutional Heating with Coal" and "Coal Carbonization" were the themes of the Twelfth Dominion-Provincial Coal Research Conference held in Ottawa this month. During the three days of the conference at Camsell Hall delegates attended three panel discussions and had the opportunity of visiting several Ottawa heating plants.

W. E. Uren, Chairman, Dominion Coal Board, was the chairman of the first symposium which concerned the preparation of coal for coke making. Dr. John Convey, Director, Mines Branch, Department of Mines and Technical Surveys, was the chairman of the two other meetings at which the theme topics of the Conference were discussed.

Mr. Uren was the chairman of the business session which was held on the morning of Oct. 15, the final day of the Conference.

(Continued on page 140)

Nominations for Officers, 1961

The report of the 1960 Nominating Committee, as accepted by the Executive Committee of Council at its meeting held on September 9, 1960, in St. Andrews, N.B., is published for the information of all corporate members as required by Sections 19 and 40 of the By-law's.

VICE-PRESIDENTS

One to be elected for two years

Zone A (Western Provinces)	**F. M. Cazalet, Vancouver, B.C.**
Zone B (Province of Ontario)	**Paul E. Buss, Thorold, Ont.**
Zone C (Province of Quebec)	**G. N. Martin, Montreal, Que.**

COUNCILLORS

Two to be elected for three years

Montreal	**T. A. Monti** **R. J. Harvey**

One to be elected for three years

Toronto	**A. M. Toye**
Ottawa	**Hugh C. Brown**

One to be elected for two years

Vancouver	**C. Peter Jones**
Vancouver Island	**L. C. Johnson**
Edmonton	**J. Longworth**
Saskatchewan	**F. W. Catterall**
Winnipeg	**G. Flavell**
Yukon	**G. B. Starr**
Central B.C.	**H. R. Hatfield**
Kootenay	**L. Williams**
Belleville	**T. E. Flinn**
Border Cities	**(C. Maurice Armstrong)** **(J. E. Dykeman)**
Brockville	**R. H. Wallace**
Chalk River	**C. E. L. Hunt**
Kingston	**S. D. Lash**
Lakehead	**D. B. McKillop**
London	**D. M. Jenkins**
Nipissing & Upper Ottawa	**J. F. Chantler**
Port Hope	**H. A. Gadd**
Sudbury	**W. B. Ibbotson**
Baie Comeau	**Emil Bodmer**
Eastern Townships	**A. S. Mitchell**
Lower St. Lawrence	**J. R. Menard**
North Shore Lower St. Lawrence	**R. W. Pryer**
Saguenay	**C. C. Louttit**
St. Maurice Valley	**J. U. Moreau**
Fredericton	**S. B. Cassidy**
Saint John	**J. W. G. Scott**
Amherst	**J. W. Wilson**
Halifax	**W. J. Phillips**
Prince Edward Island	**L. A. Coles**
Corner Brook	**H. B. Carter**
Newfoundland	**V. A. Ainsworth**

President's Column

PRESIDENTIAL visits to important Canadian Engineering and Scientific organizations continued through the summer, culminating in a visit to the Ottawa laboratories of the National Research Council.

During this visit the President was accompanied by: Garnet Page, General Secretary; Hugh Brown, chairman of the Ottawa Branch; Dr. John Ruptash, Dean of Engineering at Carleton University; and Dr. George Glinsky, Head of the School of Engineering at Ottawa University.

The arrangements were in the capable hands of the Chairman of the EIC Committee on Technical Operations, Dr. B. G. Ballard, Vice-President (Scientific) of N.R.C. A great many interesting developments were inspected, including the new Supersonic Wind Tunnel now being erected.

The visit permitted improved liaison between the Institute and our largest scientific research group, the N.R.C.

A considerable amount of EIC attention has been focused recently on the handling of matters relating to membership administration. The ad hoc committee on membership problems, with Mr. Brown as chairman, has met several times. It is hoped that a report on the Committee will be available for study at the next meeting of the Council. Institute membership is a vital subject and is receiving careful consideration.

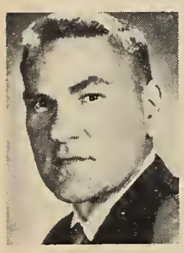
The President and General Secretary, accompanied by their wives, started a tour of the Branches in the Atlantic Provinces and Eastern Quebec early in September, Vice-President and Mrs. T. C. Higginson were with the Presidential group during the Maritime visit. Vice-President and Mrs. Charles Miller were present during the Eastern Quebec portion. This tour included attendance at the Maritime Professional Engineers Meeting at St. Andrew's, N.B.

Many of the Branch Chairmen have answered the President's recent letter to the Branches concerning the necessity for early consideration of next season's activities. It has been encouraging to note the amount of care and interest which has been shown in these replies. They will be given careful study, after which the President will send another letter to Branch Chairmen with suggestions they may consider for their autumn programs. The secret of the success of any organization is largely in careful planning. Any effort which Branch Executives make in this direction will undoubtedly be demonstrated in more effective Branch operations.

• MONTH TO MONTH

(Continued from page 138)

Roger J. Harvey New Councillor



Roger J. Harvey was elected Councillor representing the Montreal Branch at the July 22 meeting of the Executive Committee of Council. He succeeds E. D. Gray-Donald, treasurer of the Institute. Mr. Harvey joined the Bell Telephone Company of Canada as an engineer in Montreal 14 years ago. He now is supervising engineer—Estimates and Design, Outside Plant Division, Egineering Department, Eastern Area. Mr. Harvey first became active in the Montreal Branch of the Institute in 1949-50 when he served as vice-chairman of the Program Committee, then as chairman of the Radio Communications Section. Subsequently he was Program Committee secretary, secretary-treasurer, ex-officio member of the Executive Council and Executive Committee member. In 1956 he became a member of the Admissions Committee.

Argentine Engineering Official Visits Headquarters

EIC headquarters was visited this summer by Senor Dante Ardigo and Senora Ardigo. Senor Ardigo is President of the Centro Argentino de Ingenieros.

By-Law Changes

Eleven amendments to the Institute's by-laws have been approved overwhelmingly by the members. In accordance with Section 80 of the by-laws these amendments, approved for ballot by the Annual General Meeting, were submitted to the membership for a letter ballot. Following are the by-laws considered and the vote totals.

By-law Number	*Yes*	*No*	*Spoiled*
27	5,460	345	8
35	5,645	164	4
29	5,741	66	6
22	5,596	212	5
28	5,661	129	23
11	5,592	211	10
18	5,496	304	13
45	5,749	24	40
48	5,757	31	25
75	5,612	189	12
45a	5,475	321	17

The by-law sections affected deal with re-admission, branch representation, Journal subscriptions, compounding of fees, affiliates, list of members, appointment of secretary, treasurer and committees, papers committee, specifications and honorary vice-presidents; as distributed to the members.

E.I.C. Elections and Transfers

A number of applications were presented for consideration and on the recommendation of the Admissions Committee, the following elections and tranfers were effected at a meeting of council on August 18, 1960.

Member: J. T. Atchison, Winnipeg; C. L. Bailey, Calgary; W. T. Bell, Toronto; R. E. Blaby, Hamilton; J. E. Bryden, Montreal; J. G. Bullivant, St. Catharines; G. E. Buteau, Montreal; D. Critoph, Toronto; J. M. Crow, Montreal; K. M. Dewar, Toronto; A. F. Eshmade, Winnipeg; P. J. Folberth, Niagara Falls; A. Frenkel, Montreal; A. J. Gegan, Niagara Falls; K. Haselsteiner, Vancouver; E. Huni, Vancouver; W. A. Jackson, Toronto; P. S. Jaffray, Windsor; D. R. J. Kay, Galt; A. Kratsios, Montreal; L. E. Lanczi, Montreal; C. A. Macdonald, Ottawa; T. G. H. McKibbin, Winnipeg; W. J. Muir, Montreal; M. T. Neill, Kenogami; T. P. O'Connor, Taylor, B.C.; J. E. G. Palmer, London, England; F. T. Phippard, St. Catharines; J. W. Powlesland, Toronto; J. J. Redmond, Toronto; R. H. Sainani, Montreal; G. Smethurst, Ottawa; P. S. Stefanidis, Montreal; L. Tass, Toronto; J. Thon, Hamilton; O. E. Uusima, Montreal; A. Verdun, Hamilton; A. K. Voss, Valleyfield; R. C. Wyld, Yukon; W. F. Zybala, Montreal.

Junior: A. E. Burwell, Dalhousie; G. E. Courtnage, Sarnia; J. R. Dalrymple, Sault Ste. Marie; C. Grunberg, Montreal; J. A. Higgins, Montreal; J. F. Kojro, Scarborough; L. A. LeBlanc, Shawinigan Falls; I. H. MacLachlan, Montreal; P. Strong, Montreal; G. D. Thomas, Moncton; I. A. Vaughan, Manchester, Eng.

Junior to Member: W. H. Agnew, Ottawa; C. H. Albright, Trail; L. D. Almack, Toronto; F. E. Barrett, Montreal; E. R. Begin, Montreal; A. J. Bennett, Sarnia; L. D. Blachford, Toronto; L. W. Blackman, Winnipeg; J. T. Bone, Montreal; G. S. Bowes, Montreal; A. L. Braund, North Bay; S. E. Bryan, Montreal; A. E. M. Cameron, St. John's, Nfld.; W. L. Hayhurst, Toronto; R. A. Cameron, S. Nelson, N.B.; W. H. Carr, Georgetown, Ont.; M. Carrier, Rimouski; R. R. Carrier, Quebec; F. G. Carrington, Toronto; G. R. Carruthers, Quebec; R. B. Cayford, Montreal; R. O. Chenevert, Three Rivers; R. G. Christie, Westview, B.C.; H. E. Cole, London, Ont.; G. B. Conquergood, Montreal; D. C. Cramm, Hamilton; R. M. Cruikshank, North Bay; D. W. Howard, Toronto; G. N. M. Currie, Montreal; L. J. Delby, Ottawa; D. G. Demianiw, Shawinigan; O. A. Dodson, Sault Ste. Marie; J. D. Dorey, Montreal; W. C. Durant, Peterborough; O. C. Edwards, Vancouver;

G. W. Fleming, Copper Cliff; P. J. Flynn, Montreal; F. H. Foord, Philadelphia, Pa.; D. C. H. Francis, Montreal; W. Fredenburg, Toronto; W. F. Fromm, Rexdale, Ont.; W. Gouldsborough, Peterborough; G. G. Green, Ottawa; P. G. Haley, Calgary; J. G. Hall, Toronto; T. E. Harris, Montreal; R. K. Haun, Arvida; G. O. Hayman, London, Ont.; F. E. Hertha, Vancouver; P. B. Hill, St. Catharines; A. K. Hugessen, Montreal; W. A. Hunka, Toronto; W. C. Hunter, Port Arthur; J. C. Hurtubise, Rimouski; W. A. Inman, Montreal; E. H. Irwin, Beauharnois; W. C. Isaac, Montreal; J. D. Jardine, Kentville, N.S.; C. H. Johnson, Montreal; K. H. Jones, Toronto; W. G. Jones, England; R. L. Kennedy, Windsor; W. W. Kennedy, Montreal; M. Lepine, Montreal; P. J. Limbert, Trail, B.C.; H. R. Lumsden, Toronto; G. A. Mackey, Montreal; W. E. Macklon, Ottawa; G. L. MacLean, Dorval; I. D. Macorquodale, Montreal; J. W. Madill, Courtenay, B.C.; D. R. Matheson, Sydney, N.S.; J. N. Matthews, Toronto; A. McCaw, Windsor; E. D. McCormick, Port Credit; J. H. McCracken, Toronto; A. G. McIntyre, Vancouver; C. S. McKinley, Fredericton; J. W. McLellan, Mexico; W. R. McMillan, Edmonton; J. P. Milette, Quebec; F. I. Morton, Malaya; D. H. Murray, Salvador, C.A.; R. W. Myers, St. John's, Nfld.; G. H. Nagel, Hamilton; J. S. Nelles, Chalk River; J. W. Nelson, Kamloops; H. Newall, Sarnia; C. R. Newton, Toronto; J. D. Nisbet, Sarnia; D. M. Norman, Ottawa; R. Otsuki, Welland; W. G. Peacock, Montreal; A. Perrin, Toronto; A. F. Pigott, Willowdale, Ont.; R. A. Pillman, Niagara Falls; W. G. Plewes, Ottawa; M. Price, Toronto; J. M. C. Profit, Toronto; C. D. Quenneville, Montreal; A. D. Rae, Lloydminster, Alta.; A. D. Reed, Dayton, Ohio; J. A. Reid, Hamilton; J. D. Richards, Montreal; W. J. Ripley, Sudbury; W. E. Rose, Sarnia; R. J. Rushka, Toronto; A. W. Saunders, Toronto; H. G. Saville, Toronto; G. P. Schwarzkopf, Cornwall; G. H. Scruton, Montreal; M. V. Shore, Toronto; C. G. Simms, Toronto; B. W. Sinnamon, Hamilton; F. W. Slingerland, Quebec; J. S. Smeaton, Ottawa; B. A. J. Smith, Quebec; G. A. Smith, Toronto; J. Soucy, Montreal; A. K. Spence, Regina; W. D. Staniforth, North Bay; N. L. Stoddart, Montreal; J. W. Strzelecki, Maple, Ont.; S. N. Teed, Houston, Texas; F. H. Theakston, Guelph, Ont.; G. R. Thim, St. Bruno, Que.; C. G. Thompson, Pensacola, Fla.; E. L. Tong, Toronto; W. I. M. Turner, Montreal; R. W. Vollett, Ottawa; A. R. Walker, Toronto; J. R. A. Walker, Toronto; R. B. Walker, St. Bruno, Que.; G. G. Wellington, Toronto; G. P. Williams, Ottawa; H. R. Young, Washington, R. E. Yule, Montreal.

Student to Member: M. De Atucha, Spain.

Student to Junior: T. R. Horn, Edmonton; F. Williamson, Banff.

STUDENTS ADMITTED

Acadia University: D. J. Perry, V. J. Pike, G. E. Richardson, S. C. K. Wong.

McGill University: R. Peterson, O. Silverman.

University of Toronto: H. F. Ryan, F. Z. Sobolak.

University of Western Ontario: G. T. Suter, J. J. Wideki.

Saint Mary's University: J. C. Y. Fung.
Nova Scotia Technical College: R. A. Barkley.

Queen's University: D. H. Zwicker, B.Sc. (Civ.) 1960.

McMaster University: J. Schroeder.

College Militaire Royal de St. Jean: P. H. Kroeger.

University of Washington: V. B. Kromand.

University of Alberta—graduates: Z. D. Figol, B.Sc.(Civ.) 1960; N. J. Kitz, B.Sc. (Civ.) 1960; J. K. F. Kwong, B.Sc.(Civ.) 1960.

University of Toronto—graduates: A. B. Hall, B.A.Sc.(Civ.) 1960; L. C. Mangoff, B.A.Sc.(Civ.) 1960; R. Partanen, B.A.Sc. (Civ.) 1960.

Student of Corporation of Professional Engineers of Quebec: A. D. Drost.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective August 18, 1960.

ALBERTA

Members: R. J. Finley, I. C. Khosla.

Junior: J. D. Thomson.

Junior to Member: C. J. Farrell, R. H. Vickerman.

SASKATCHEWAN

Members: S. B. Bell, L. B. Brunskill, G. M. Doucet, D. R. Gillard, G. W. Grass, B. A. Holmlund, P. Kents, D. M. Lane, H. Olecko, M. W. Pyke.

Juniors: W. Westgaest.

Junior to Member: H. F. Button, J. W. Chepha, D. J. Ferguson, A. A. Gorkoff, G. F. Hutch, E. H. McIntyre.

Student to Junior: M. T. Dagg, B. J. Pfeffer, D. L. MacLeod.

Students: J. Wolkowaski, R. E. Wood.

NOVA SCOTIA

Members: F. C. Farrell, A. R. Howard, A. R. MacLean, J. Nagy.

Junior to Member: W. R. Lowther.

MANITOBA

Member: W. H. Bender.

Junior to Member: G. S. C. Smith.

Members with No Addresses

The following members' mail has been returned to headquarters. As a result, their names have been removed from the Institute membership list, but would be readily reinstated if a current address were forthcoming. Information regarding them should be sent to: **Records Department, The Engineering Institute of Canada, 2050 Mansfield Street, Montreal.**

Members
Schuett, George Herbert, Ottawa; Tammik, Kaljo, St. Lambert, Que.

Juniors
Archambault, Pierre A., l'Abord-a-Plouffe, Que.; Bonneville, Jacques Marcel, Quebec; Bressler, Theodore, Ingersoll, Ont.; Collis, James Dean, Pte. Claire, Que.; Cook, Richard Moxley, Toronto; Ferris, Charles Raoul, Edmonton; Fisher, William Henry, Vancouver; Heaney, William Creighton, Montreal; Laberge, J. Peter, Montreal; Lamarche, Paul, Montreal; MacDonald, William Grant, Wiltshire, England; Monaghan, Dennis James, Springfield, N.J., U.S.A.; Overhill, Douglas Tom, Montreal; Paquet, Andre, Quebec; Potter, Gary William, Vancouver; Preston, Keith S., Hamilton; Ross, John St. Clair, Toronto; Roy, Guy Walter, Montreal; Sikal, John Derick, Schefferville, Que. & Toronto; Simard, Jacques P., Montreal; Vosniades, Orpheus, Montreal; Watkins, Raymond Herbert Cyril, Calgary.

Students
Arseneault, Lionel Raymond, Montreal; Bagnall, Ralph Simpson, Charlottetown, P.E.I.; Baron, Roger Jack, Calgary; Blowatt, Kenneth John Richard, Burlington, Ont.; Bowes, Robin Neale, Ottawa; Bowkett, Edmund George Alfred, Winnipeg; Choquette, Roger, Quebec; Christensen, Flemming Henrick, North Surrey, B.C.; Cossette, Marcel, Ottawa; Crooks, Archibald Muir, Jamaica, B.W.I.; Frazer, George Robert, Vancouver; Fulford, Gerald Nelson, Kingston; Hamilton, James Murray, Weyburn, Sask.; Heimark, Harry, Saskatoon; Hersey, Donald Ersel, Fredericton; Hopkins, James Alfred, Halifax; Kappel, John James, Montreal; King, Arthur Emmerson, Halifax; Lecocq, Donald Stanley, Ottawa; Lescuk, John, Toronto; Lum, Peter, Ottawa; Magee, William George, Edmonton; McIntosh, Robert Gordon, Saskatoon; McIntyre, Harold Robert Bruce, Toronto; Myint, Maung Soe, Rangoon, Burma; Olafson, Wayne Allen, New Westminster, B.C.; Pedroso, Hector M., Havana, Cuba; Poulin, Gregoire, Noranda, Que.; Prevost, Marcel Joseph Denis, Sherbrooke, Que.; Provencher, Thomas, Ottawa; Rooney, Francis Joseph, Lancaster, N.B.; Roylance, Campbell Arthur, Winnipeg; Skinner, Antony Simon, Montreal; Strachan, Robert Allan, Vancouver; Swantee, Frank Murray, Pictou Co., N.S.; Topper, Timothy Hamilton, Cooksville, Ont.; Tremblay, Daniel, Timmins, Ont.; Vlahos, George, Montreal; Wells, Lyle Edgar, Ingleside, Ont.; Whitcombe, Richard Milner, London, Ont.

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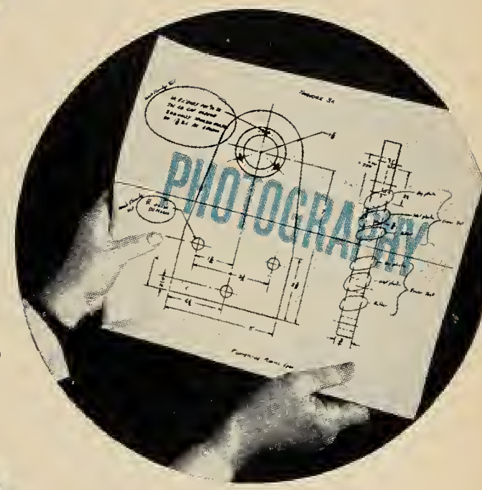

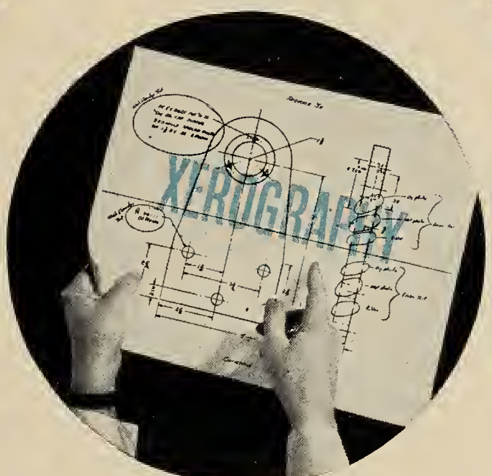

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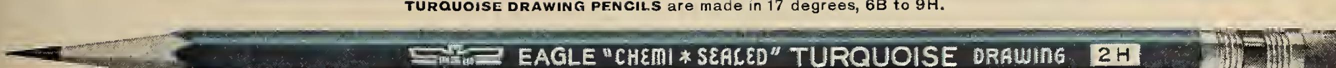

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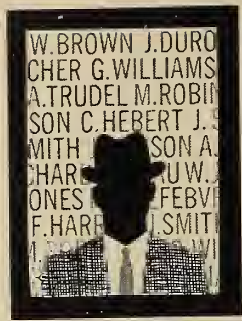
Personals



Richard M. Dillon, M.E.I.C. (M.I.T. '50) has assumed his duties as Dean of the Faculty of Engineering Science at the University of Western Ontario. Mr. Dillon, who was born in Simcoe, Ont., received his university education at U.W.O. and at the Massachusetts Institute of Technology. During the Second World War he served with the Royal Canadian Regiment and with the General Staff in England, Sicily and Italy. He was awarded the Military Cross for conspicuous service with the R.C.R. in Sicily, and later was wounded in action in Italy. After completing his interrupted education he joined the Design Staff of the Dominion Bridge Company, Limited in Toronto and later became a partner and Director of M. M. Dillon and Company, Limited. For the past eight years he has been head of the Structural Department and has served as Chief Project Engineer. While accepting his new appointment he will continue to serve as a Director and Consultant with M. M. Dillon and Company.

R. M. Dillon, M.E.I.C.

William J. Riddell, M.E.I.C., (Manitoba '24) has been awarded by the Canadian Good Roads Association a special scholarship for post-graduate study in civil engineering. The scholarship is known as an International Road Federation fellowship. Mr. Riddell is an assistant design engineer with the Saskatchewan Department of Highways and Transportation, Regina.

J. Edgar Dion, M.E.I.C. (McGill '24) has recently moved his consulting management engineering offices from the Canada Cement Building to 1980 Sherbrooke Street West, Montreal 25.

Noel Wright, M.E.I.C. (Illinois '28) has been appointed Special Industrial Representative in charge of the New York City office of Southern Canada Power Company Limited.

J. H. Mellor, M.E.I.C., (McGill '30) has been appointed assistant manager-engineering, at Canadian Copper Refiners, Montreal East.

F. Milligan, M.E.I.C.

Frank Milligan, M.E.I.C., (Toronto '48) of Thermal & Hydraulic Equipment, Limited, Toronto, has been appointed sales agent for Ontario by Morris Machine Works, Baldwinsville, N.Y., manufacturers of centrifugal pumps and hydraulic dredges.

L. P. Beaulieu, M.E.I.C. (Ecole Polytechnique '34) has been eleeted vice-president and a director of the Canadian Fairbanks-Morse, Company, Limited. Mr. Beaulieu also will serve as vice-president and general manager of Dynamic Engineering Limited, recently purchased by C. F. M. It will be operated as a C. F. M. subsidiary.

John R. Michie, M.E.I.C., (Toronto '40) has been appointed manager of Frick of Canada, Limited, with head office in Montreal, a subsidiary of Frick Company, Waynesboro, Penn.

Walter H. Ball, M.E.I.C., (Saskatchewan '41) has been appointed Officer-in-Charge of the British Columbia Regional Station, Building Research Division, of the National Research Council.

D. D. Munro, M.E.I.C. (Saskatchewan '45) has been appointed Resident Engineer of the Iroquois Falls Division of Abitibi Power and Paper Company, Limited. Mr. Munro formerly was Resident Engineer, Manitoba Paper Company, Limited, at Pine Falls, Man.

Eric E. Heaton, M.E.I.C., (Queen's, Belfast '47) has formed a new company, Nova Scotia Drilling and Equipment, Limited, Bryant Building, Halifax, N.S. He will serve at president. Mr. Heaton also has established recently a consulting firm in the field of soil mechanics and allied sciences, Eric E. Heaton and Associates, Consulting Soil Engineers, Halifax.

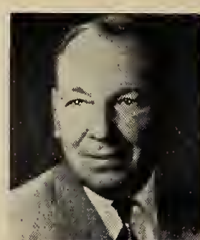
Karl W. Allcock, M.E.I.C., (Sask. '48) has been appointed electrical distribution manager, Saskatchewan Power Corporation, Regina. Mr. Allcock joined the SPC in 1948 and in 1952 was named operating supervisor and assistant to the operating superintendent. In 1957 he was appointed operating superintendent.

G. Valois Bourbonnais, M.E.I.C. (McGill '40) has been appointed chief engineer of Pigott Construction Company's Quebec Division.

Keith Vail, JR.E.I.C., (N.S.T.C. '50) has been appointed resident engineer of construction at Isle Maligne, Que., for the Aluminum Company of Canada. Mr. Vail previously was associated with Pigott Construction Company and the Foundation Company Quebec at Montreal.

W. M. Kelly, M.E.I.C., (Toronto '50) has been appointed vice-president and general superintendent, distribution, for The Consumers' Gas Company.

C. E. Bedford-Jones, M.E.I.C. (Toronto '33) president of F. S. B. Heward and Company, Limited, who recently acquired the interests of Mr. Heward in



C. E. Bedford-Jones, M.E.I.C.

H. E. G. Dupuy M.E.I.C.

the company, has announced that **H. E. G. Dupuy**, M.E.I.C. (McGill '38) has become a partner in the firm and will assume the duties of vice-president and general manager. Mr. Dupuy was eastern branch manager for Babcock-Wilcox and Goldie-McCulloch, Limited. Bedford-Jones also announced the company, while continuing to represent the same manufacturers of steam plant, industrial and marine equipment, has changed its name to Canapower Thermal Specialties, Limited.

(*More Personals on page 147*)

• PERSONALS

(Continued from page 144)

John A. Kerr, M.E.I.C., (Manitoba '52) has taken a position with the Water Resources Division of the Ontario Water Resources Commission.

William A. Porter, JR.E.I.C., (Alberta '56) has joined the editorial staff of Heavy Construction News as Technical Field Editor.

Pierre C. Lefrancois, JR.E.I.C., (Ecole Polytechnique '56) has obtained a master degree from the Graduate School of Industrial Administration, Carnegie Institute of Technology. Formerly with Shawinigan Chemicals, Mr. Lefrancois now is with the commercial development department of Cyanamid of Canada.

J. W. Barnes, JR.E.I.C., (McGill '57) has joined IRC Resistor Division of Renfrew Electric Company of Toronto as chief engineer.

D. E. Stothers, JR.E.I.C., (McGill '58) formerly serving as an officer with the Canadian Army in West Germany, has been selected to attend a Guided Missiles Staff Officers course with the United States Army at Fort Bliss, Texas.

O. J. Hahn, JR.E.I.C. (Alberta '58) has been awarded his master's degree in nuclear engineering at West Virginia University.

Among senior engineering students at nine Canadian universities who have been awarded prizes by the Canadian Construction Association for theses on construction subjects were: **J. O. Bursey,** S.E.I.C.; **J. A. Craig,** S.E.I.C.; **Raymond Goyette,** S.E.I.C. (Ecole Polytechnique '60); **J. Hiley,** S.E.I.C. (Manitoba '60); and **B. A. Lundeen,** S.E.I.C.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Address all information to:
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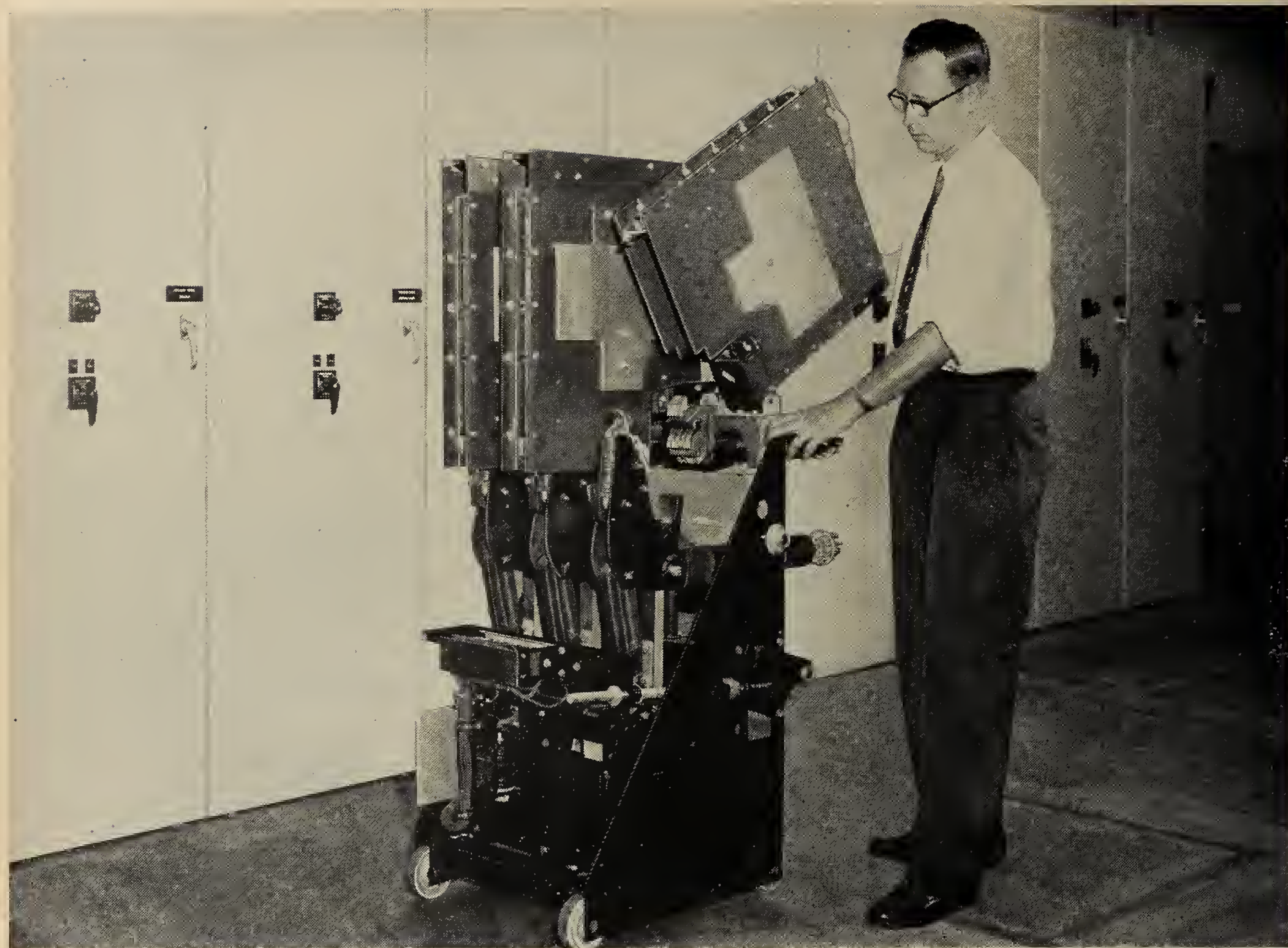


Group of stainless-clad steel digesters

Other Societies

European Chemical Engineers

G. McK. Dick, president of the Institute, will be a patron of the European Convention of Chemical Engineering to be held in Frankfurt, (Main), June 9-17, 1961. The ACHEMA 1961 also will take place within the framework of the convention.

Included in the program will be: a symposium on "The Physical and Chemical Durability of Structural Materials in the Chemical Industry"; special meeting and lectures 1961 of The Gesellschraft Deutscher Chemiker; and the annual meeting 1961 of the Isotopen-Studiengesellschaft.

American Society of Mechanical Engineers

Henry T. Heald, president of the Ford Foundation, has been selected an Honorary Member of the A.S.M.E. for "effective and faithful service to the engineering profession and to the public."

National Association of Corrosion Engineers

Corrosion resistance to various metals will be discussed in two papers to be presented in Montreal Novemeber 14-16 at the Canadian Region session of the N.A.C.E.

Regional N.A.C.E. meetings in the United States in October and November will be held in Tulsa, Okla., Huntington, W. Va., San Francisco, Milwaukee and Atlanta.

"Stress-Corrosion of Austenitic Chromium-Nickel Stainless Steels," a review of 129 case histories and information on current research activity has been published jointly by the American Society for Testing Materials and N.A.C.E.

The book is available from A.S.T.M. or from N.A.C.E., 1061 M & M Bldg., Houston 2, Tex. Cost is $6 to non-members of either society, $4.80 to members.

Canadian Construction Association

The C.C.A. has published Proceedings of its annual meeting in Calgary last January. Included are: Statement of Policy and Resolutions passed; Code of Practice; the President's address and 15 other major speeches; reports of 14 C.C.A. standing committees; reports of four major C.A.A. sections; and a list of those who attended the convention.

This is available from the Public Relations Department, Construction House, 151 O'Connor St., Ottawa 4.

Oak Ridge Symposium

A five-day symposium during which university staff members were informed of concepts and progress in the controlled thermonuclear field was held at Gatlinburg, Tenn., Aug. 22-26.

The symposium — "An Introduction to Thermonuclear Plasma Physics" — was sponsored jointly by Oak Ridge National Laboratory and the Oak Ridge Institute of Nuclear Studies.

John Fritz Medal Winner

Stephen D. Bechtel, president of Bechtel Corporation, San Francisco is the 1961 recipient of the John Fritz Medal, awarded annually for notable achievement in the engineering profession.

Established in 1902 to perpetuate the memory of John Fritz' achievements in industrial progress, the medal is sponsored by the American Society of Civil Engineers, American Institute of Mining Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers and the American Institute of Chemical Engineers.

Finland's Institute for Technical Research

A number of publications and report series covering wood, metal and electricity, building, and chemistry, have been produced by the State Institute for Technical Research. These are available from the State Institute, Helsinki, Lonnrotink, 37, Finland.

Petroleum Mechanical Annual Conference

The Petroleum Division of the American Society of Mechanical Engineers held its national conference in New Orleans last month. Fifty-seven papers were presented during 26 technical sessions.

International Atomic Energy Agency

Six new publications have been prepared by the International Atomic Energy Agency in Vienna. These deal with research on controlled thermonuclear fusion, disposal of radioactive waste, use of radiation in industry and medicine, and bibliographic information.

The publications, which range in price between $1 and $6, may be ordered from the Publications Sales Unit, International Atomic Energy Agency, Kaerntnerring 11, Vienna 1, Austria. The bibliographies list is free.

American Concrete Institute

The A.C.I. has published a new bibliography, "Fatigue of Concrete", which lists and annotates 114 significant works published since 1898 on the fatigue of plain and reinforced concrete. Copies

(Continued on page 155)

The Associations and Corporation

A report on scholarships and student loans is contained in the June issue of The Alberta Professional Engineer, published by the Association of Professional Engineers of Alberta.

Two Edmonton students attending University of Alberta were awarded $200 bursaries for achieving the highest general standings in the first year of Engineering and of Geology. Arie Reedyk was awarded the Engineering bursary—The H. R. Webb Memorial Scholarship.

Geology student Alice Victoria Payne won the John A. Allan Memorial Scholarship.

The Association's annual report also noted 12 outstanding student loans totalling $2,380. The report was contained in the minutes of the Association's 40th annual meeting, held in Edmonton.

Also contained in the publication were committee reports to the annual meeting, and notes on Algeria's Messaoud oil field.

Obituaries

Alexandre Albert Belanger, M.E.I.C. retired District Engineer of the Board of Transport Commissioners for Canada, passed away on July 22, 1960, at his home in St. Hyacinthe, Quebec. He was 82.

Educated at Ottawa University, Mr. Belanger went to Montreal in 1895 and worked on land surveying and municipal engineering for several consulting firms until 1901. He then joined the engineering staff of the Canadian Pacific Railway, working first in Montreal, then in Calgary. In 1910 he was appointed District Engineer of the Board of Transport and he held that post until his retirement in 1943.

Mr. Belanger joined the Institute in 1899 and was awarded Life Membership in 1944. He was also a member of the Association of Professional Engineers of Ontario.

Morton Farrer Cochrane, M.E.I.C., a retired senior civil servant. He was 77.

Mr. Cochrane joined the old Department of the Interior in 1905, and retired in 1947 from the Department of Mines and Resources.

He was born in Galashiels, Scotland, and was educated at Trinity College, Glen Almond; Heriot Watt College, Edinburg; and the Royal Technical College, Glasgow.

He worked with a Glasgow civil engineering firm from 1900 until he emigrated to Canada five years later.

Mr. Cochrane joined the Interior Department in the topographical surveys branch, transferred to the international boundary branch in 1907 and to the water power braneh in 1917.

M. F. Cochrane, M.E.I.C.

The first St. Lawrence Deep Waterway Treaty of 1932 was prepared by Mr. Cochrane. This treaty was rejected by the United States Congress.

Later he drafted agreements between Canada and the United States and between the Federal and Ontario governments for development of St. Lawrence-Great Lakes navigation and power.

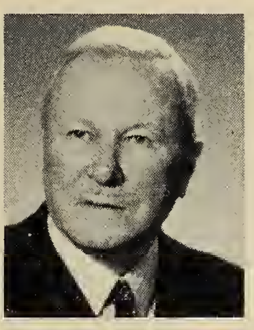
He represented Canada at an international power conference in London in 1925.

Author of a history of water power in Canada, Mr. Cochrane also prepared briefs used in many national and international water conferences and negotiations.

Mr. Cochrane became a member of the Engineering Institute of Canada in 1926, and 20 years later was named a life member. He was an associate member of the Institute of Civil Engineers.

In 1908 he was commissioned a Dominion Land Surveyor.

James Colin Kemp, M.E.I.C., prominent Montreal engineer and executive, died August 20. He was 78.



J. C. Kemp, M.E.I.C.

Mr. Kemp was born in London, England and was educated at Clifton College and University College, Oxford, where he obtained a Bachelor of Arts degree. He received his B.Sc. at McGill in 1908.

After leaving McGill, Mr. Kemp joined the Consolidated Mining and Smelting Company of Canada in British Columbia, later he worked at Drummond Mines, Cobalt, Ont., and R. A. Ross and Company, Montreal consulting engineers.

From 1926 until 1934 he was employed by the National City Company, Limited, after which he transferred to the staff of Dominion Stores, Limited, as manager of the Montreal division.

In 1937 Mr. Kemp became executive director of the Home Improvement Plan. Eight years later he was appointed managing director of George S. Armstrong and Company (Canada) Limited, industrial engineers and management consultants.

Since 1951 Mr. Kemp had been a consulting engineer.

Mr. Kemp was a member of the Engineering Institute of Canada, the Corporation of Professional Engineers of the Province of Quebec, and of the Canadian Institute of Mining and Metallurgy.

J. S. H. Wurtele, M.E.I.C., retired executive of several power companies, died August 6, 1960. He was 79.

Mr. Wurtele was retired vice-president and director of the Southern Canada Power Company, plant manager of the Power Corporation of Canada, Montreal, and president and director of Dominion Electric Protection Company, Toronto, Ont.

He was born in Acton Vale, Que., and received his higher education at Bishop's University, Lennoxville, Que., and at McGill.

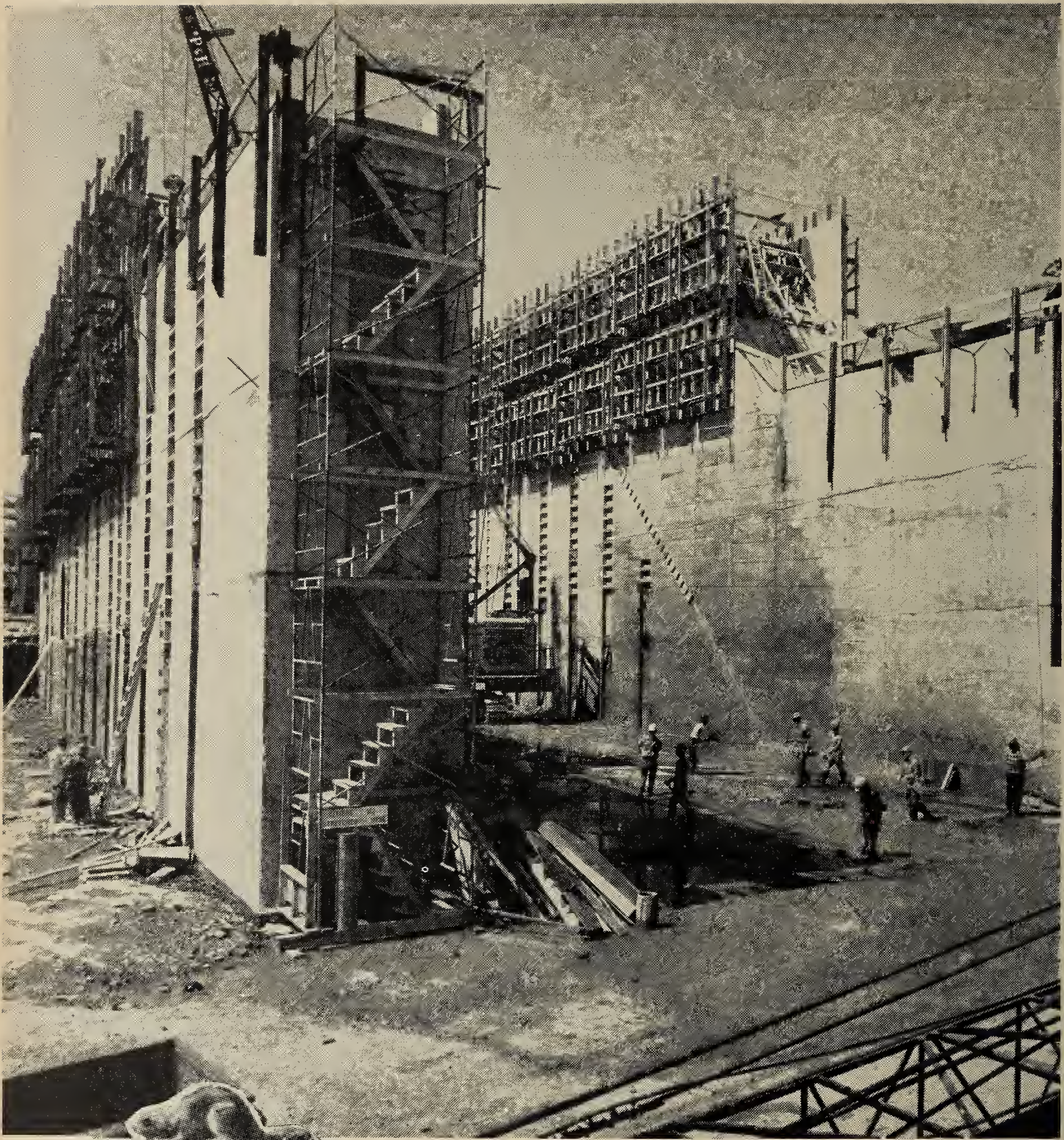
His association with power development began in Quebec province and continued in Vancouver and in the state of Washington.

From 1913 until 1917 he was manager of the power department of Algoma Steel Corporation, Sault Ste. Marie, Ont. The following year he joined Southern Canada Power and later became vice-president and plant manager of that firm, and subsequently of the Power Corporation of Canada.

Mr. Wurtele retired in November, 1956.

He became a member of the Engineering Institute of Canada March 20, 1917 and was named a life member of the Institute January 1, 1951.

Mr. Wurtele also was a member of the Corporation of Professional Engineers of Quebec, Ontario, British Columbia and New Brunswick; an associate member of the American Institute of Electrical Engineers; and of the University Club, Montreal, the Lions Club, Acton Vale, and of Delta Upsilon Fraternity.



• OTHER SOCIETIES

(Continued from page 152)

may be obtained from the A.C.I. p.o. box 4754, Redford Station, Detroit 19, Mich. Cost is $2.50.

International Conference on University Reactors

Outstanding authorities on various aspects of reactor construction, operation and education led an international conference on university reactors at Gatlinburg, Tenn., in August.

The conference was intended to benefit universities which have not yet undertaken reactor programs, as well as those institutions now operating reactors. Sponsors were the Oak Ridge National Laboratory, the Oak Ridge Institute of Nuclear Studies, and the Oak Ridge Section of the American Nuclear Society, in co-operation with the United States Atomic Energy Commission.

In addition to about 150 representatives of 40 American colleges and universities there were delegates from Canada, the United Kingdom, Belgium, France, Israel and Japan.

American Society of Civil Engineers

A research conference and three sessions on professional matters supplemented a technical program during the A.S.C.E. annual convention in Boston, October 10-14.

During 39 technical sessions 146 technical papers were presented. There also were panel discussions and joint division sessions.

Coming Events

Power Industry Computer Application Conference, St. Louis, Mo., November 9-11.

Sixth annual conference on magnetism and magnetic materials, New York City, November 14-17.

Symposium on Engineering Applications of Probability and Random Function Theory, Lafayette, Ind., November 15-16.

Second International Reinforced Plastics Conference, London, England, November 30-December 2.

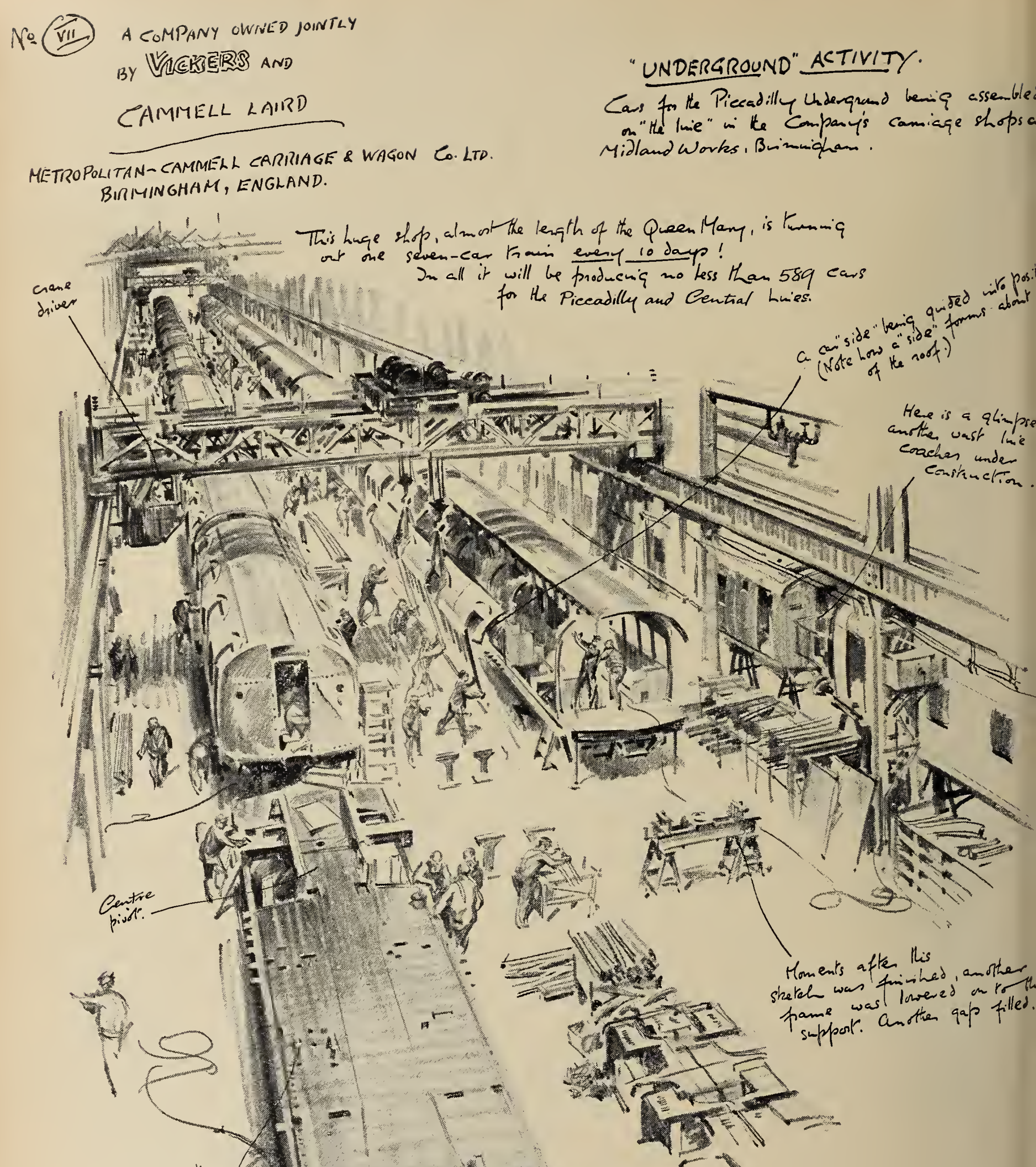
Institute of Radio Engineers, Vehicular Communications, annual meeting, Philadelphia, December 1-2.

Electrical Insulation Conference, Chicago, December 5-8.

1961 SAE International Congress and Exposition of Automotive Engineering, Detroit, Mich., January 9-13, 1961.

Canadian Textile Conference, Montreal, Queen Elizabeth Hotel, February 7-9, 1961.

1st International Congress on the Mechanics of Soil-Vehicle Systems, Turin, Italy, Polytechnic Institute, May, 1961. EIC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In all it will be producing no less than 589 cars for the Piccadilly and Central Lines.
Crane driver
A car "side" being guided into posi… (Note how a "side" forms about … of the roof.)
Here is a glimpse … another vast line … coaches under construction.
Centre pivot.
Moments after this sketch was finished, another … frame was lowered on to th… support. Another gap filled.
underframe ready for the first sections of the body to be lowered into place.
CUNEO
Next commission:- COOKE, TROUGHTON & SIMMS Ltd at YORK. (Gives me a chance … visit the Railway M…

News of the Branches

The biennial meeting of the Atlantic Provinces Professional Engineers, held at St. Andrews, N.B., Sept. 7-9, was the largest formal gathering of engineers ever held in the Maritimes. The meeting was sponsored by the Atlantic provinces branches of the Institute and by the Associations of Professional Engineers of Nova Scotia, Prince Edward Island, Newfoundland and New Brunswick.

In addition to area officers who served on the meeting committee, Institute representation included President George McK. Dick and general secretary Garnet T. Page. General chairman of the meeting committee was J. B. Eldridge, chairman of the Saint John Branch. P. J. Delicaet of Bathurst, chairman of the Northern New Brunswick Branch, was one of three joint chairmen. The general secretary of the meeting committee was J. P. Mooney, secretary-treasurer of the Saint John Branch. J. J. Donahue, an Institute Councillor, was a member of the two-man finance committee.

Two professional sessions were held during the meeting. J. E. Hayes, M.E.I.C., Montreal, Chief Engineer for the Canadian Broadcasting Corporation, presented a paper dealing with "The Television and Radio Facilities of the C.B.C."

Canada's rocket program was outlined by Irvine B. Cameron of Ottawa, superintendent of the propulsion wing of the Canadian Armament Research and Development Establishment. Research on rocket propulsion began in 1956, Mr. Cameron said, and static and flight tests have been held since then at Valcartier, Que., and at Fort Churchill, Man.

One aspect of CARDE's studies has been the development of economical rockets for upper atmosphere investigations. A slender, 24 ft. test vehicle, the Black Brant, was fired a year ago from Fort Churchill with several hundred pounds of instruments. It is being used for upper atmosphere studies at 50 miles. A high-altitude missile, the Black Brant II, has been designed with lighter components and a longer-burning engine. Mr. Cameron said Black Brant II, which is to be launched from Fort Churchill, should carry a 100 lb. payload 75 miles into the atmosphere.

"Combined Thermal-Hydro Development" was discussed in a paper prepared jointly by the New Brunswick Power Commission and H. G. Acres and Company, Limited. The other paper, "Corrosion in Action," was presented by R. J. Law of Oakville, Ont., a member of the Development and Research Division of the International Nickel Company of Canada Limited.

Luncheon speakers were E. B. Ross, mayor of St. Andrews, Mr. Dick, and G. B. Williams, Assistant Deputy Minister of the federal Departmnet of Public Works. Lieutenant-Governor J. Leonard O'Brien of New Brunswick addressed the final dinner assembly of the meeting. The Chignecto Canal program was outlined by Brigadier J. M. S. Wardell of Fredericton.

Newfoundland Branch Chairman J. P. Henderson introduces Institute President G. McK. Dick, immediately to his right, at a Presidential dinner at St. John's.

Newfoundland

Anthony Nemee, JR.E.I.C.,
Correspondent

Institute President George McK. Dick and general secretary Garnet T. Page were guests of the Newfoundland Branch at its banquet and dance Sept. 10. Mr. Dick, guest speaker at the banquet, discussed the Institute's objectives.

Suitable leadership and encouragement for Canadian engineers are provided by the Institute, Mr. Dick said. For their part, engineers have many responsibilities in our rapidly-changing world. The Canadian engineer must avoid an attitude of complacency, he said, and must continue to improve if Canada is to meet successfully foreign competition. The Presidential party visited the campus of the $12 million Memorial University which is scheduled for completion early in 1961.

Members of the Branch's new executive are: J. P. Henderson, chairman; A. Butt, vice-chairman; A. E O'Reilly, secretary treasurer; and C Conroy; R. Martin; E. Ball; A. Nemec; M. Tomlinson; D. Sharpe; G. Neary.

Saguenay

Maurice Simard, JR.E.I.C.,
Correspondent

Dr. D. T. Wright, Dean of Engineering at the University of Waterloo, was the guest speaker at a Sept. 15 joint technical meeting of the Institute Branch and of the Saguenay Chapter of the Corporation of Professional Engineers of Quebec.

The curriculum for engineering students at Waterloo consists of alternate periods of study and practical experience in industry. This course of study and related subjects were outlined by Dr. Wright.

The Branch and the Saguenay Chapter of the C.P.E.Q. have chosen a joint executive. Its members are: D. L. Aker, chairman; P. R. Brais, vice-chairman; J. R. Eason, secretary; and councillors A. Pinault, D. H. Hobbs, D. A. Findlay, M. Lavallee, J. J. M. Falardeau and M. Simard. The past chairman is D. W. Stairs.

Autumn Programs

Few of the Branches were active during the summer but several had plans to start their autumn programs. Members and guests of the **BORDER CITIES BRANCH** scheduled a mid-September tour of the H. J. Heinz plant at Leamington, Ont. **CALGARY** began its fall activities with its annual barbecue which followed a Membership Tea held by its Engineers Wives Club. **HAMILTON BRANCH** has scheduled its annual Engineers' Dance for Nov. 5. The Waterloo Fish and Game Club was the site of a stag held by the **KITCHENER BRANCH.** Mr. Dick was guest speaker at a September dinner meeting of **MONCTON BRANCH,** held at the Beaver Curling Club. A dance followed. The **OTTAWA BRANCH,** through the courtesy of Mines Superintendent Edwin R. Tyler, scheduled a field trip to Hilton Mine Sept. 24. The Athabasca Tar Sands were to have been discussed at the Branch's Oct. 6 meeting.

Tour

M. Pierre Danel, M.E.I.C. of France, one of the world's foremost authorities on hydraulics, has scheduled visits to 16 Branches in October and early November. His tour was to have started Oct. 11 in Montreal and is scheduled to end in Chalk River, Ont., Nov. 4. Following is M. Danel's proposed itinerary:

Tuesday, Oct. 11 — Montreal
Wednesday, Oct. 12 — Three River, Que.
Thursday, Oct. 13 — Baie Comeau, Que.
Monday, Oct. 17 — Sydney, N.S.
Tuesday, Oct. 18 — Halifax
Wednesday, Oct. 19 — Moncton, N.B.
Thursday, Oct. 20 — Ottawa
Monday, Oct. 24 — Trail, B.C.
Tuesday, Oct. 25 — Vancouver
Wednesday, Oct. 26 — Victoria
Thursday, Oct. 27 — Edmonton
Monday, Oct. 31 — Saskatoon
Tuesday, Nov. 1 — Winnipeg
Wednesday, Nov. 2 — Toronto
Thursday, Nov. 3 — Kingston, Ont.
Friday, Nov. 4 — Chalk River

M. Danel, president and general director of SOGREAH, is noted for his contributions to many phases of hydraulics and from 1933 until 1945 was in charge of courses at the Ecole des Hydrauliciens de Grenoble and Directeur of the Laboratoire Hydraulique of the University of Grenoble. He is past president of the Association Internationale de Recherches Hydrauliques and is a member of thirteen technical societies and associations in France, Canada and the United States. EIC


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• DISCUSSION

(Continued from page 132)

Niagara Falls, Ontario. Both these, and the agreement for a large 30,000 kva. iron smelter at Kingston, Ontario, are commercial sized units.

These actual facts, based on signed contracts, and work now in construction, as well as developments in many other situations, such as the announced plants of Texas steel groups, a Mexican steel group, and others we are not at liberty to disclose, can only demonstrate a wide gamut of acceptance of the advantages of Strategic-Udy.

It would actually appear to us at this time that Strategic-Udy is indeed the very process most likely to supplement the classic blast furnace, and conventional cold charge low shaft electric furnace.

One of the principle developments that the Process has made possible is that of economic smelting of either pig iron or semi-steel, (as well as ferromanganese and ferrochrome), direct from low-grade or contaminated ores, black sand deposits, high copper, high sulphur ores, high titania magnetites, and even fine concentrates, without agglomeration.

In addition, selective reduction has made possible the production of carbon steel and valuable stainless steel from the well-known laterite deposits of the world, as well as low cost production of ferromanganese and ferrochrome from ores that have not been used to date.

The process does not require coke but can use carbon in almost any form. We have had our best successes with use of lignites and high (47%) volatile coals, but any coal, coke breeze, petroleum residue, (even wood chips), can be used.

In the considered opinion of many of the world's specialists in electric furnace techniques, as well as metallurgists of Elkem, Koppers and others who are familiar with electric smelting, the development of the Udy furnace is a basic and fundamental step in the history of pyrometallurgy.

There are three main reasons behind this statement:

Firstly, the Udy smelter is the only furnace that permits the practical utilization of the benefits of preheat and prereduction.

Secondly, it makes possible the practical use of selective reduction and produces a molten product.

Thirdly, it is self-contained and highly economical with respect to energy utilization and it does not require metallurgical coke nor any agglomeration of the charge, since the furnace has no "burden", and fines are normally smelted.

At the same time, of course, the Strategic-Udy Process can easily and economically produce either pig iron or semi-steel direct from high-grade blast furnace type ores.

We think it entirely significant to note that neither the blast furnace, nor the submerged arc low shaft electric furnace, can successfully digest the titaniferrous ores or fines, or nickel-chrome laterites, and this factor is fast becoming of great economic importance.

In addition, the Process produces a molten iron or semi-steel that is ready for foundry use, or, more particularly, for economic refining into quality carbon steel.

There are so many locations in Canada, U.S.A. and other parts of the world where on-site smelting with local raw materials is of vast economic importance that Strategic, Koppers and Elkem, (and others), feel that Strategic-Udy has now emerged as the successful "direct reduction" process.

THE POTENTIAL IN THE FREE PISTON ENGINE PRINCIPLE

A. Braun, *Vice President,*
Free Piston Development Company Ltd., Kingston, Ont.

The Engineering Journal, July, 1960, p. 57.

Author's reply to the discussion by J. D. Fleming.

Most of the many papers referred to by Dr. Fleming are either reporting on, or at least based on reports, of the only free piston gasifier, commercially available to date the GS34 or General Motors version of this unit the GM14. This unit is rated at about 1250 G.H.P. and hundreds of European units have been made and sold and are giving satisfactory service. Since so much has been written on these first units and relatively little written about the possibilities in the basic principle, the above paper was prepared, a fact apparent from its title.

As to the relative values of the air standard and actual gasifier efficiencies the author fails to see Dr. Fleming's point since this question was strongly emphasized by Fig. 6 in which the common trend of the theoretical and actual efficiencies is shown, and where the difference in value between the thermal and actual efficiency accounts for compressor and turbine losses as well as all other losses that cannot be accounted for in an air standard analysis.

Regarding Dr. Fleming's remarks concerning Fig. 3 and the so called "by-pass gas", as mentioned in the paper to avoid confusion references were made to confirm that in the air standard analysis the effect of the "by-pass gas" on efficiency cancels out. The reason for basing the different analyses on the air standard cycle and quoting in Fig. 6 the air standard efficiencies was to stimulate creative work and thus serve the purpose of the paper, the pointing out of the potential instead of repeating figures reported in previous papers.

In this very sense the air standard approach still best serves its old and intended purpose.

The difference between volumetric compression ratio and pressure ratio was defined unmistakenly and the common error referred to by Dr. Fleming was avoided in the paper. The figures quoted in his discussion in this regard are strictly based on GS34 conditions. Engines with overall volumetric compression ratios of 40 to 1 have been tested successfully. Concerning future compression ratios the last paragraph of the paper should be referred to.

The point discussed by Dr. Fleming in regard to multifuel characteristics is practically stated in the first sentence under this sub-heading in the paper and a quite comprehensive picture is given of the existing conditions in the engine. The author agrees that with heavy fuel wear rates increase but in this regard new approaches particularly in view of this new principle, seem possible.

It has been mentioned in the past that the unavailability of suitable auxiliary equipment is a serious drawback in the development of the free piston engine, which is a fact that at times really effects development work. Aside from this short range problem numerous suitable auxiliary devices have been developed which should, once quantities are required, result in lower prices and adequately answer this problem. In one of the author's designs of 80 G.H.P. size this question has been solved quite satisfactorily. Turbines for these small sizes are of the supercharger type and can in quantity be manufactured at very reasonable costs.

The problems quoted under Multiple Gasifier Installations can be greatly influenced by the designer particularly in regards to control, and the free piston principle poses no greater engineering problem than comparable conventional installations.

The author fully agrees with the last paragraph of Dr. Fleming's discussion particularly that free piston engines have their place in the power field. As to the selection of the individual engines available it should again be emphasized that it was not the purpose of the paper to give data and information on what is available but rather to point out the basic potential in the free-piston principle and encourage designers to approach this development with maximum creative freedom, asking for new approaches to explore it.

Much of the development in the Free-Piston field has been restricted to following the lead of others and putting together of old ideas and means found in related fields, and what is worse, making predictions based on this type of analysis. Considerable cautiousness in accepting the free-piston engine can be attributed to this situation. The design engineer should not neglect what has been established but this end cannot be the major part in a healthy creative process.

Dr. Fleming's interest in the paper is very much appreciated and it is felt that had the actual paper been available earlier permitting more careful study of it, it would have eliminated many of the questions raised however this discussion has permitted re-emphasizing the paper's purpose.

MINERAL RESOURCE DEVELOPMENT IN NORTH AND WEST

John Convey

Department of Mines & Technical Surveys, Ottawa

The Engineering Journal, September 1960, p. 66

Author's reply

I am thankful to S. W. Schortinghuis, M.E.I.C., for his comments related to the additional services of government departments other than the Mines Branch whose work is related to the development of Canada's resources.

It is my pleasure to inform Mr. Schortinghuis that the policy of the Mines Branch is to encourage wherever possible the growth of mineral research facilities in Canadian industrial and provincial departments. This sharing of the development problems would free Mines Branch from the many day to day problems which require immediate solution. Such co-operation will enable the Mines Branch to employ its staff and facilities in the solution of the more difficult complex and long-term problems which are directly related to the growth of the Canadian mining, mineral and metallurgical industry. Such research is needed if we expect to hold a competitive position in the modern mineral world market. It is in this way that we may be regarded as showing a greater tendency towards so-called basic research. However, our effort will always be intimately associated with Canadian industry.

In reply to J. S. Roper, I regret that shortage of time prevented me from elaborating on the various Mines Branch divisional functions. However, it is a pleasure for me to expand my remarks in reply to his two questions.

The first as associated with the work of the Branch in the field of industrial minerals. This part of the Canadian mineral scene was once considered lowly in relation to metallics. Industrial minerals covers the wide field of non-metallic minerals, sands, clays, rocks and industrial waters. These commodities have grown immensely in stature during Canada's rapid industrial growth of the past decade. It is true to say that probably no other segment of the mineral industry has had to lean so heavily on the Mines Branch for assistance, first because the problems for investigation in industrial minerals are almost infinite, secondly, because most of the industrial minerals have a low unit value and the industry is therefore

not in the position to support extensive scientific investigations.

The Branch maintains an up-to-date source of information concerning the variety, quality, and availability of industrial mineral resources in Canada. This inventory is maintained through extensive field studies in addition to the research associated with the development of methods of beneficiating products from low-grade deposits that are required to meet the exacting specifications of modern industry. Typical examples of our technical work are:

(1) the development of a brucitic limestone in Quebec;
(2) the rock wool industry;
(3) the production of refractory materials from Canadian kyanite deposits;
(4) the correlation and study of the physical and chemical properties of asbestos in relation to industrial applications;
(5) the development of ceramic electronic components.

These are but a few of the many examples which could be quoted concerning the work of the Branch which covers the development of the Canadian industrial mineral phase of the country's economy.

In addition to the Western Regional Laboratory of the Mines Branch in Edmonton, we also have a group located in Calgary whose work is directly associated with the coal industry of the Alberta foothills. A similar outstation is found in the Maritimes where mining engineers and physicists are actively engaged in the study of ground stress mechanics as found in the Maritime coal mining operations. We also have a physical metallurgical officer attached to the British Columbia Research Council in Vancouver. His work is to give direct assistance to the metallurgical industry of British Columbia.

WATER SUPPLY AND SEWERAGE AT URANIUM CITY

H. P. Klassen, M.E.I.C.
Underwood, McLellan & Associates Limited, Saskatoon
The Engineering Journal, September 1960, p. 61

Author's reply

In answer to questions regarding the system it is quite likely that due to the recession of population below design value that localized areas would experience some freezing. This applies particularly to the Uranium Road section which has a separate trunk sewer draining a small section which has not developed as expected. In a case such as this the corporation would be well advised to consolidate the remaining householders and discontinue service in these isolated areas.

The design of the sewerage system is along conventional lines for Western Canada. The minimum depth is nine feet, with manhole spacing from 300 to 400 feet. Generally the water mains were laid two feet higher than sewer mains to comply with the Public Health Department's requirements.

The material used for building service connections was asbestos-cement building sewer pipe and copper water service pipe. The water pipe was wrapped with an electric thaw wire then securely taped to the sewer pipe. The wire used was a No. 10 copper with weather-proof insulation which was fastened to the main stop and taken right into the building. A transformer is supplied to the householder at a reasonable charge, connected to the thaw wire and plugged into a convenience outlet of the household electric system.

The water supply is of excellent quality chemically as well as bacteriologically requiring no treatment except chlorination to meet the requirement of the Department of Public Health. The domestic consumption was not a critical design factor. The minimum flow requirement in the supply main, to prevent freezing, determined the minimum pumping capacity. This volume of water is more than enough to provide domestic demand.

Fire demand is provided by separate fire pumps driven by electric power and also by a standby gasoline engine in event of power failure. The capacity of the fire pump is 1,200 g.p.m. at a head of 190 feet. As mentioned in the paper the looping arrangement allows feeding of any hydrant from both directions. The hydrants are not the standard in normal use but adapted to on-line installation to eliminate dead areas subject to freezing. Drainage sumps were installed to provide barrel drainage.

The discussion presented by Mr. Sladek is a worthwhile addendum to this paper. It points out that each ensuing project must be designed with a view to all the variable conditions of temperature and soil conditions and that standardization of northern systems cannot be considered with the limited knowledge at hand. The continuous development of new materials especially in insulation materials will improve economy in both installation and operation.

LIQUID PETROLEUM GASES AS FUELS FOR AUTOMOTIVE ENGINES

H. A. Spencer, M.E.I.C.
Research Council of Alberta, Edmonton.
The Engineering Journal, July 1960, p. 62.

Author's reply:

Boyd Candlish, M.E.I.C., makes several interesting technical points about the paper. The first is that major modifications are not required to obtain suitable efficiencies with LPG engines. This point may be correct in that special engine materials are not needed, but conversion of a normal engine still costs in the range of $250-$300, especially since a tank of sufficient strength must be provided.

With regard to efficiencies, I do not agree with Mr. Candlish that propane engines can obtain a thermal efficiency of 40%. Increasing the compression ratio beyond 9 to 1 brings a diminishing return on efficiency, and causes heat timing problems even with propane.

Exhaust gases were mentioned only briefly but two companies in the United States now manufacture propane-diesel equipment for reducing smog on large trucks, the cost of which is considerably less than $200.

My thanks to Prof. W. Alexander, M.E.I.C., for his kind remarks. His question about exhaust gases is well taken. Certainly this is an immediate source of heat and one which could, as he says, be immediately responsive to demand. Certain mechanical problems arise, however in the transmission of heat at 750°F to a gas which must activate rubber diaphragms and valves. Perhaps materials have held back work on this prospect. However it is certainly worth investigation and trial, and I acknowledge the suggestion with thanks.

KELSEY GENERATING STATION DAM AND DYKES

R. A. Pillman, Jr.E.I.C., D. H. MacDonald, M.E.I.C., H. R. Hopper, Jr.E.I.C.
The Engineering Journal, October 1960, p. 87.

Author's reply:

The authors wish to thank Professor A. Baracos, M.E.I.C., R. Peterson, and Messrs. H. B. Dickens and G. H. Johnston for their discussions. Professor Baracos has raised the interesting questions of (1) the desirability of installing pore pressure and settlement measuring devices in the Kelsey dam, and (2) the method of analysis employed to ascertain the rates of thaw and of moisture dissipation as the permafrost beneath the dykes thaws.

Consideration was given to the need to measure pore pressures and settlement in the core of the dam, but in view of the practical difficulties involved in doing this in a dam of the sloping core type, and because of the probable interference with the construction operations and the high cost of such installations it was decided not to do so. Such results would be extremely interesting in view of the type of material used for the core, but they would have had no effect on the design of the Kelsey dam. For this reason reliance had to be placed upon the laboratory test results and an adequate factor of safety provided for all eventualities.

Analyses to determine the rate of thaw beneath the dykes were made by standard methods of heat flow theory. Analyses to establish the rate of moisture dissipation were based upon the results of pore pressure dissipation tests and standard consolidation theory for radial and vertical drainage. These studies indicated that consolidation would keep pace with thawing and that no excess pore pressures would occur. Publication of discussions of these methods is planned later when field data now being obtained are sufficient to allow fair comparison of predicted and actual measurements to be made.

AQUEDUCT AND PUMPING STATION FOR GREATER WINNIPEG

N. S. Bubbis, M.E.I.C.
R. C. Sommerville, Jr.E.I.C.
Greater Winnipeg Water District
The Engineering Journal, August 1960, p. 43

Discussion by K. E. Patrick, M.E.I.C.

May I first congratulate Mr. Nat Bubbis and Mr. Sommerville on a most interesting and informative paper. The description of the various problems that were met in the design and construction of the Second Branch Aqueduct and Low Lift Pumping Station and the solutions to those problems make a valuable contribution to the technical literature.

As one might expect, local conditions were the predominant factor in the design and construction of the Red River tunnel and similarly in the design of the low lift pumping station. This is not unusual in such specialized projects and should create no surprise.

The design of a pipe line, however, even a major one, might be expected to have a more universal application and be less affected by local conditions. But, after Mr. Bubbis' and Mr. Sommerville's paper and with some knowledge of the Greater Vancouver Water District's pipe lines, it struck me forcibly that local conditions may be of paramount concern in their design also. It is about this aspect that I would like to comment.

The Greater Winnipeg Water District in the design and construction of its Second Branch Aqueduct met and coped with the following local conditions. Active sulphate soil, clays subject to large volumetric change with changing moisture content, soil movement, a relatively low static head, a large variation in water temperature through the year and an unusually long pipe line that can tend to produce high surge pressures or water hammer.

By comparison, the Greater Vancouver Water District, I am most happy to say, has none of these problems. In fact the only similarity is that we both must move large quantities of water continuously from where it is to where it is needed.

That doesn't mean that we have no problems. We do. But they are different ones and are met in different ways. Rugged topography, steep side hills, many different types of soil, which while generally chemically inactive, vary from solid igneous rock to glacial tills, to unconsolidated gravels and sands, to silts and clays, high static pressures — up to about 300 p.s.i. and mountain streams capable of very great variations of flow. The rough topography results in pipe lines with numerous bends and curves, both horizontal and vertical, which when coupled with high heads, present anchorage problems best met with pipes having longitudinal strength. Welded steel pipe meets this requirement admirably and thus we have a great liking for it. It is protected inside with a spun lining of coal tar enamel and outside with coal tar enamel protected in turn with asbestos felt wrapping. This has given excellent service in our location, but you can readily see that the Greater Winnipeg Water District first did not have the rough topography nor the high pressures to contend with and second did have a serious soil condition to consider. This difference in local conditions therefore affects the design criteria to such an extent that the type of pipe best suited to one location is different from the type of pipe that is best for another.

Where we have to install a sufficient length of main that is reasonably straight and under light to medium pressure, we also, like the Greater Winnipeg Water District, call for alternative tenders, but in our case the main call is for steel pipe with reinforced concrete pipe the alternative. In the past twenty-five years, steel pipe has underbid concrete pipe whenever such alternative was permitted.

I was most interested in the requirement of the Specifications for the Branch II Aqueduct that the contractor meet a particular roughness coefficient. I believe this is unusual, but it certainly is logical. After all, the whole purpose of spending a large sum of money is to obtain water in quantity at the downstream end. Any reduction from the design flows means that the owner has not obtained what he contracted for. As long as the co-efficient chosen is reasonable, then any values less must be caused by a poor pipe surface or by poor laying. When you note that both the quality of the pipe and the quality of the pipe laying can affect the roughness coefficient, the wisdom of a "turn-key" contract becomes apparent.

Checks on the carrying capacity of new coal tar enamelled pipe of 72 in. and 54 in. diameter indicate a roughness coefficient in Mannings formula of "n" = 0.010 to 0.011 which, I believe, is comparable to a Hazen Williams "C" of 140.

It will be most interesting to hear what coefficient is actually achieved by the Branch II Aqueduct. I'm sure the results will fully justify the consideration, care and hard work that has gone into the design and development of this project.

Discussion by A. E. Barry, M.E.I.C.

The paper by Messrs. Bubbis and Sommerville contains a number of interesting features, and the Greater Winnipeg Water District has over a period of years demonstrated a foresight that is not always present in dealing with problems of this nature. It is desirable to comment on the steps taken so early as 1912 to bring water from Shoal Lake. The project at that time must have been considered a tremendous one, and one which few municipalities to-day would be inclined to face without serious difficulties. The foresight and wisdom of that decision has undoubtedly meant much to the people of the Winnipeg area over these number of years. It is also of interest to note that the measures that were taken in this area nearly 50 years ago are now being attempted in other places in order to safeguard the water supply and growth of the future in those communities.

The development of a water project such as this involves many difficult problems. Not only is there the question of the design of the pipe line itself, but there is the need for protection of the water at its source. In this instance this is a supply which involves two provinces, Ontario and Manitoba. It would be most unwise to spend the money required for such a project without ensuring both an adequate supply and one that will be of good quality to serve the various consumers. Up to the present, there has been little difficulty in protecting the quality of this water. Steps will need to be taken to ensure that as development goes forward in the vicinity of this lake the water quality will not be impaired in any way.

One of the major problems of engineers who are dealing with water supply is forecasting the consumption over a long period in advance. This has been especially so in recent years. The engineers who were responsible for the decisions in the Greater Winnipeg Water District acted wisely, and in looking back over the years since this development occurred one must pay tribute to their foresight and good judgment. If the developments in the future can be predicted with anything like the same degree of accuracy the engineers of today will have much to be proud of.

Reference is made to problems that have arisen in this water supply involving algae growths. These have occurred in surface waters for a number of years. They appear to be increasing in recent years, and steps are being actively taken now to provide measures which will counteract these growths. It is the feeling that in so far as this supply is concerned there are no particularly abnormal conditions to stimulate the growth of algae, but it is obvious that special measures are necessary to keep these growths within reasonable limits.

One of the interesting aspects of this entire project, as well as the additions now being made, is that it is serving an area rather than separate municipalities making provision for their individual supplies. It is most desirable that water problems be regarded on an area basis and boundary lines be forgotten. It is to the advantage of all to have this method of attack followed. This is the program that is now being developed

A GROWING YOUNGSTER

and *idb*

Some youngsters grow so fast that they are always pushing out of their clothes and needing new ones. This was the sort of problem faced by the X-Y Company. Not only was the company's growth phenomenal but new developments in the character and manufacture of the product—foil and transparent paper—had extended its common use into foodstuffs, tobaccos and other perishables and even into the hardware and textile fields. The Canadian consumer was increasingly being offered the cleanliness and convenience of having more and more goods pre-wrapped.

The X-Y Company's growth demanded more machinery and space; the new diversity in wrappers demanded new equipment. The X-Y Company had been doing extremely well, but it had been growing out of its financial clothing. When it first approached Industrial Development Bank for financial assistance, it already owned a plant which was fully paid for. Annual sales were over the million dollar mark, and heading higher.

The growth in market demand was most encouraging but in the endeavour to keep up with it, the company had been unable to set aside funds for adequate expansion. Its assets were substantial but normal commercial financing was not available and the company was not in a position to issue further capital stock successfully. I.D.B. stepped in to provide the needed financing and the productivity of the new machinery quickly fulfilled the highest expectations.

But the youngster hadn't stopped growing, and the same situation arose a couple of years later. Again the company needed new machinery to increase production and again I.D.B. provided the term financing for this purpose. The mushrooming sales chart took another surge upward.

The X-Y Company has benefitted from having alert, courageous management and from having the right goods to sell at the right time and, when opportunity knocked, I.D.B. financing helped the company to open the door.

The I.D.B. was established in 1944 to assist industrial enterprises whose term financial needs cannot be met from normal sources. By extending financial assistance, I.D.B. endeavours to help an enterprise to take advantage of expansion possibilities and progress through its own efforts.

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in the Province of Ontario through the Ontario Water Resources Commission. The action taken in the Province of Manitoba in the case of the Greater Winnipeg Water District was an example of forward thinking.

A good deal of study has gone into this work for the extension, and the District has not failed to consult others who may have knowledge and skill to assist in the problem. This method of attack is one to be commended in all such projects.

One can only conclude from a comprehensive paper such as this that the City of Winnipeg and adjacent municipalities have over the years shown leadership in engineering and administration which has resulted in benefit to all concerned. There is little doubt but that the steps now being taken will prove beneficial in the years ahead.

Discussion by L. R. Howson

Mr. Bubbis referred to the method of calling for tenders. As the "turnkey" method was adopted following United States practice, possibly some discussion of the factors influencing the decision to follow that procedure in this case may be of interest.

The scope of work as outlined in the specifications consisted of "designing, manufacturing, supplying, installing, testing and placing into operation a 5 ft. 6 in. diameter pipe line." Sometimes in the United States as will be later referred to, alternate tenders are requested on pipe line materials and their installation separately and the decision is based upon the bids received. In this instance tenders were asked only on the "turnkey" procedure. Alternate specifications were, however, prepared and bids taken on prestressed reinforced concrete and on welded steel pipe with cement mortar lining and coal-tar enamel with double bonded fiberous glass mat and asbestos felt wrapping. This taking of alternate tenders on competitive materials also followed a procedure common in the United States.

Among the advantages believed to result from the "turnkey" type of contract for large pipe line work are the following:

1. It centralizes responsibility which eliminates dispute between pipe manufacturers and the installation contractors relating to such items as delivery, breakage or damage.

2. As Mr. Bubbis pointed out a high "C" Hazen & Williams value was important, a variation of one point below 140 being evaluated at $42,000. While it is believed "C" will exceed 140 as specified, it would be much more difficult to fix the responsibility in case of failure to reach 140 if one contractor made the pipe and another contractor installed it. The "turnkey" procedure is adapted to enforcement of the penalty provision for failure to meet the carrying capacity coefficient.

3. On several comparable jobs in the United States, the contractors have been given the option of a "turnkey" job or bidding separately for either or both items of furnishing materials and for installation. In most cases the overall cost to the purchaser has been bid lower under the "turnkey" alternative.

Among factors contributing to this lower cost of the "turnkey" job are—

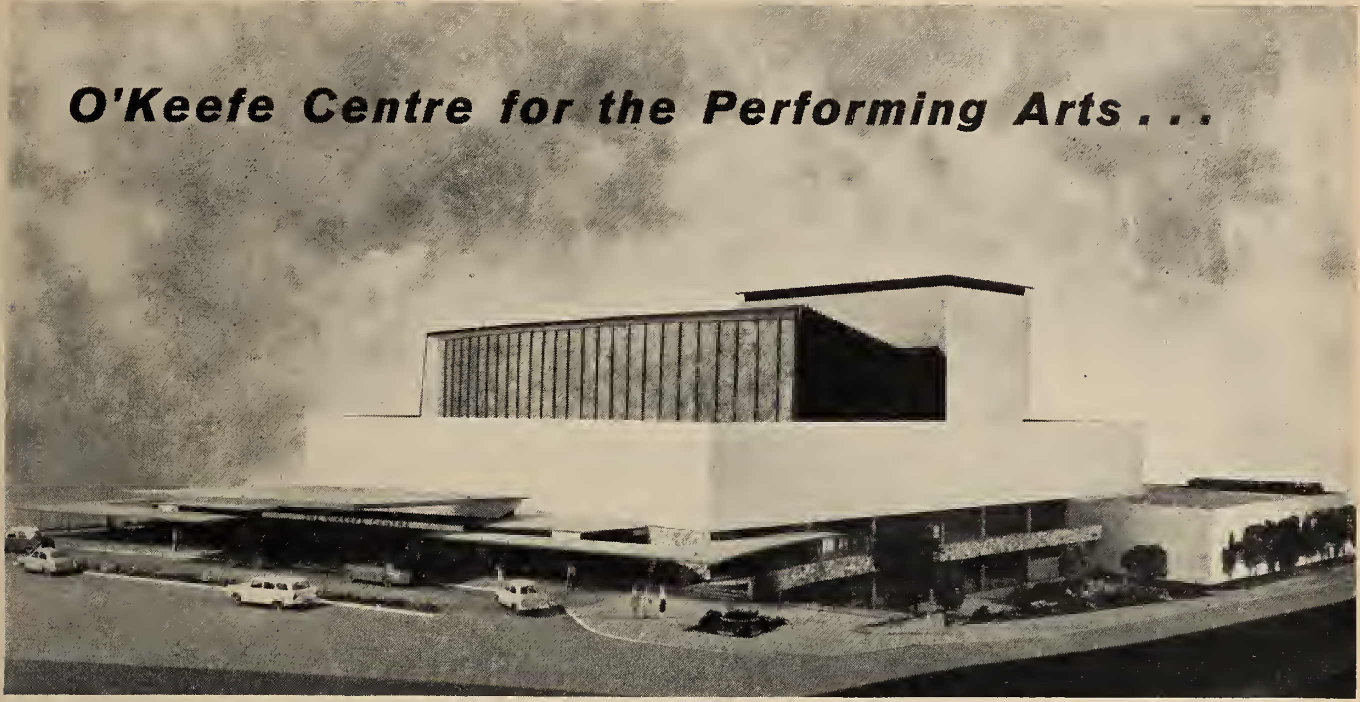
(a) Most of the difficulties experienced in large pipe line work have resulted from the manner of installation. The correction of such deficiencies involves costs to the pipe manufacturer as well as to the installation contractor.

Under the "turnkey" type of contract the manufacturer either installs his own pipe or selects as subcontractor for the installation, some contractor with whom he has had prior satisfactory experience. He therefore can figure the pipe at a lower price than he can offer it to a purchaser who will select the pipe laying contractor competitively and wholly independent of the manufacture. This introduces an element of contingency usually reflected in the price bid.

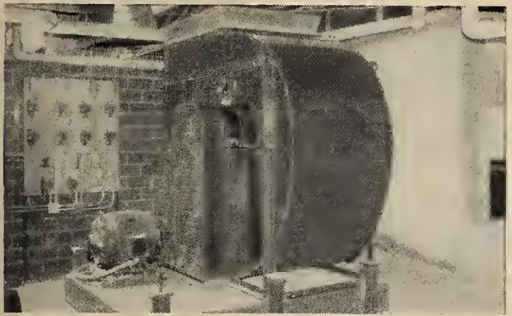
(b) Pipe materials are in constant competition. By bidding through contractors of their own selection, with whose proficiency they are well acquainted, the manufacturer can and frequently does sell the pipe at a lower price than he would bid openly and competitively. In so doing he has not disclosed his normal competitive price.

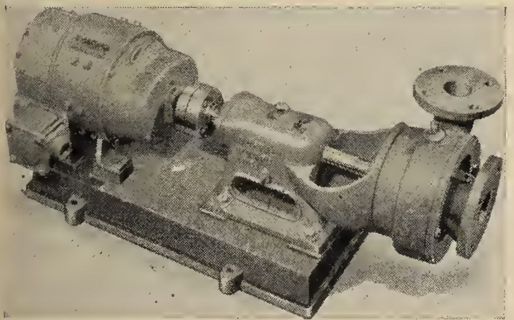
(c) Where a single contractor is responsible for the entire job the making and laying of the pipe can be better co-ordinated with resulting economy.

On each of three pipe line contracts, (of 83 miles, 28 miles and 23 miles) on which the tenders provided for either separate bids on materials and installation or alternate bids on concrete and steel pipe and for a "turnkey proposal", there was substantial advantage in favor of the latter. Our experience has been that, in addition to the financial advantage, the administration of the "turnkey" type of contract is simpler and more satisfactory, both to the owner and to the contractor. EIC



DEPENDS ON TOP QUALITY 'CANADIAN BUFFALO' FAN AND PUMP PERFORMANCE





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Library Notes

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Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

*REINFORCED CONCRETE RESERVOIRS AND TANKS, 4th ed.

A practical treatment of the design and construction of plain and reinforced concrete reservoirs, tanks, swimming pools, and other water-containing structures above and below ground level, omitting water towers and hollow reinforced concrete dams. The book includes ideas from continental practices, and selected methods of design are treated in detail, the author giving his conclusions as to the simplest solutions for various designing problems. (W. S. Gray. London, Concrete Publications, 1960. 188 p., $2.80.)

*TRANSFORMERS AND GENERATORS FOR POWER SYSTEMS.

A British translation of the original French text. Both transient and steady-state conditions are studied. In addition to chapters dealing with and developing the fundamentals, there are survey chapters giving general treatment to practical aspects of special problems. The volume is divided into two books. Book 1 discusses the transformer, covering electromagnetic theory, windings, insulation, losses, voltage regulation and phase connection, with survey chapters on abnormal conditions, special types of transformers and transformer construction, technical literature, and the particular interests of the specification and the operating engineer. Book 2 deals with the synchronous machine under similar relevant headings. (R. Langlois-Berthelot. New York, Philosophical Library, 1960. 541 p., $12.00.)

*WATER AND AGRICULTURE.

The sixteen pages in this symposium on the agricultural use of water were prepared by experts in the respective fields, and were presented at a 1958 meeting of the AAAS. The papers are arranged in four major groups: water for the future; water sources; water planning and use; and water control. They touch on power, industrial, recreational, and other uses of water only where these impinge on agricultural uses. (ed. by R. D. Hockensmith. Washington, D.C. American Association for the Advancement of Science, 1960. 198 p., $5.00)

*HYPERSONIC FLOW.

Fifteen papers constituting the proceedings of the 11th symposium of the Colston Research Society (Bristol, England, 1959). They cover surveys and details of experimental facilities, techniques for simulating hypersonic flight conditions in the laboratory, investigation of the properties of gases at elevated temperatures, theoretical solutions of particular flow problems, and studies of the configuration, propulsion and kinetic heating of vehicles designed for hypersonic flight. (Ed. by A. R. Collar & J. Tinkler. Toronto, Butterworth, 1960. 432 p., $13.50.)

*ELECTROMAGNETIC ENERGY TRANSMISSION AND RADIATION.

This is the text for one of the eight subjects of the new undergraduate "core curriculum" being evolved by M.I.T. in Electrical Engineering. It treats electromagnetic waves and oscillations by discussing the important linear-system concepts of the time and frequency domains, and the energy-power relations from the theories of lumped circuits and quasi-static fields, extending them to cover "distributed" situations, in which space assumes an importance equal to that of the other independent variables. The objective is to provide a four-way viewpoint-time, frequency, energy (or power), and space. (R. B. Adler. New York, Wiley, 1960. 621 p., $14.50.)

ACRONYMS DICTIONARY.

Everyone plagued by the use of incomprehensible abbreviations and strings of initials will welcome the appearance of this dictionary of "telescope words." It is concerned primarily with abbreviations originating in the United States for U.S. government and military departments and their terminology, but enough of the terms are in common use in Canada to make this volume essential in every library and office. It also includes acronyms for American associations and corporations, as well as for phrases in general, and not so general use. The longest phrase for which an acronym seems to have been found is E.S.P.W.O. for "Exigencies of the Service having been such as to Preclude the issuance of competent Written Orders in advance," while it is to be hoped nobody ever has to use W.W.III (World War 3). (Detroit, Gale, 1960, 211 p., $10.00.)

*ELECTRICAL EFFICIENCY IN INDUSTRIAL PLANTS.

The aim of this book is to assist in the identification and elimination of power loss in industrial plants, from small tool shops to large steel mills. Such elements as preliminary system planning and analysis of systems and circuits, utility rate structures, selection of voltage levels, conducting and interpreting surveys of load, power factor, voltage, lighting, wiring and grounding, selection and purchase of electrical instruments, and optimum inspection and maintenance procedures are discussed. General principles are illustrated with detailed examples from actual practice. (E. S. Lincoln. New York, Dodge, 1959. 235 p., $9.50.)

*HOCHSPANNUNGSTECHNIK, 4TH ED.

The new edition of this German work on H-T technique incorporates all changes and innovations in the field since the third edition (1950). There are new chapters on the increased efficiency of transformers of relatively smaller dimensions and on switching installations and switches which today are meeting the demands of considerably higher power loading. Also considered is the progress in creating high D.C. voltage, in the technique of X-Ray rules, and in R-T equipment for nuclear physics. There is an extensive bibliography arranged according to chapters. (A. Roth. Vienna,

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

Austria, Springer-Verlag, 1959. 756 p., $39.00.)

*THE EXPLORATION OF SPACE

This is a survey of recent developments in the space sciences presented in individually-authored papers, originally presented at a Symposium on Space Physics in 1959. Included are discussions of the nature of the moon, Venus and Mars; solid particles, plasma and magnetic fields in the solar system; astronomy from rockets, satellites and space vehicles; and a survey of the present frontiers of space and the major problems of the future. (ed. by R. Jastrow. Galt, Brett-Macmillan, 1960. 160 p., $5.50.)

*SMALL GAS TURBINES.

This book covers gas turbines ranging from 30 b.h.p. up to about 1,500 b.h.p., emphasizing the medium output engines, and concentrating on their adaption for other than aircraft propulsion purposes. Included are examples of applications for portable and stationary power purposes, for light aircraft and aircraft piston-engine take-off boosters, for guided missiles, and for automobiles, small marine engines, and turbines operated by high-pressure boiler exhaust gases. (A. W. Judge. Toronto, Ryerson, 1960. 328 p., $9.75.)

*DESIGN AND PERFORMANCE OF GAS TURBINE POWER PLANTS.

This volume is designed to provide a basic source of present-day knowledge in the field of aircraft gas turbines. Combustion chamber design includes the basic requirements and processes of the system, experimental techniques, fuel injection, flame stabilization, mixing processes, fuels to be used, and developmental considerations, The mechanics of materials and flutter problems are covered in the following section, and finally the various performance criteria which are used in the design of the engines are considered. *(High Speed Aerolynamics and Jet Propulsion Volume XI)* (Ed. by W. R. Hawthorne, Toronto, Saunders, 1960. 563 p., $17.25.)

*IP STANDARDS FOR PETROLEUM AND ITS PRODUCTS,
Part I. METHODS FOR ANALYSIS AND TESTING. 19TH ED.

Beginning with this 19th edition, the Institute will publish its Standards in four volumes. Volume 1 comprises all the general laboratory methods which form the major portion of the I.P. Standards and includes certain small scale rig tests, specifications for I.P. Standard hydrometers and thermometers, and a table giving equivalence of ASTM and IP methods. (Published by Institute of Petroleum, London, England, 1960. 783 p.

*KINEMATICS OF MACHINES, 2nd. ed.

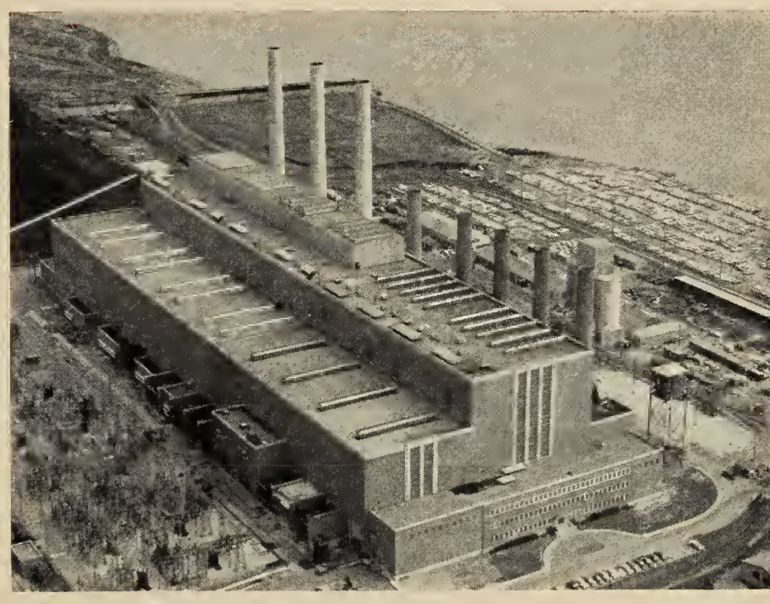
Revisions in this edition include more extensive treatment of Coriolis' acceleration, and new discussions of the four-bar linkage, independent-position and finite difference equations for velocity and acceleration analyses, the theory and application of complex variables for cam design, and Bennett's linkage. There are three entirely new chapters, on dimensional synthesis, mechanical computing mechanisms, and constrained motion and number synthesis. (R. T. Hinkle. Englewood Cliffs, N.J., Prentice-Hall, 1960. 353 p., $7.50.)

*OPERATIONS RESEARCH AND SYSTEMS ENGINEERING.

Lectures by authors from the fields of physics, economics, statistics, psychology, engineering and mathematics for a course for management at Johns Hopkins. Discussed are the philosophical and historical aspects of systems engineering and operations research, and specific methodologies such as statistical quality control, linear programming, the theory of games, information theory, and feedback. Case histories involving war games, a hospital, newspaper operations and a telephone company conclude the volume. (ed. by C. D. Flagle. Toronto, Burns & MacEachern, 1960. 889 p., $18.00.)

*INCOMPRESSIBLE AERODYNAMICS.

The first book of a new series, the Fluid Motion Memoirs, this volume provides a comprehensive review of certain flows of incompressible fluids and is a theoretical and experimental study of the uniform flow of air and other viscous fluids past two-dimensional aerofoils and three-dimensional wings. Related topics



such as flows past joined bodies, shear flows, rotary flows, and boundary-layer control are also dealt with. The information contained here is essential for those in aerodynamics, and is also applicable to areas such as gas turbines, pumps, compressors, ventilating systems, ships' stabilizers, and river erosion. (Ed. by B. Thwaites. Toronto, Oxford Univ. Press, 1960. 636 p., $11.25.)

*DESIGN OF MODERN STEEL STRUCTURES, 2nd. ed.

Joints and connections as rivets, welds, bolts, pins and timber connectors are treated first and then design of members. Both treatments relate the theoretical concepts to the field of design through specifications, which are referred to by official number. Four important structures are presented as major design examples—a building girder and a roof truss designed for both welding and riveting, a low-truss riveted highway bridge, and preliminary design of a multi-story office building with welded joints. Major changes in this edition involve the substitution of ultimate load design for continuous beam design, and emphasis on plastic design considerations. (L. E. Grinter. Galt, Brett-Macmillan, 1960. 491 p., $10.00.)

*AUTOMATIC REFRIGERATION.

This book surveys the aims, principles, and techniques of refrigeration, and the principles of automatic control, studies the design, functions and applications of automatic controls and fluid flow regulating devices, and presents extensive photographs and descriptions of existing automatic refrigeration plants, mainly European. There is an extensive section of operating information, which includes calculation sheets such as those for heat transfer, fluid flow, and plant lay-out operations; conversion tables and tables of meteorological, physical, design and other data; refrigerant tables in both British and metric units; and a bibliography and extensive literature survey. (S. A. Andersen. London, Eng., MacLaren & Sons, 1959. 649 p., 85/-.)

DIRECTORY OF UNIVERSITY RESEARCH BUREAUS AND INSTITUTES.

A guide to U.S. and Canadian bureaus, institutes, experiment stations, laboratories, etc., which are set up on a permanent basis, and carry on continuing programmes of research in specialized fields.

It contains some 1500 listings in over 200 fields, including engineering, chemistry, physics, mining, geology, operations research, computer and data processing facilities, community planning, transportation, etc. For each bureau information given includes sponsoring body, address, year founded, name of director, size of staff, publications, and a description of activities.

This should prove a most useful guide. (Detroit, Gale, 1960. 199 p., $20.00.)

*PROGRESS IN AUTOMATION, Volume 1.

This first volume of a proposed series contains eleven papers from leading British experts in the field of mechanical automation, recording progress in the United Kingdom in devices for industrial control. Following an introduction to the field, with a brief historical note and definition of terms, are six papers covering analogue conversion techniques, process control systems, position control of machine tools, the inductosyn, nucleonic gauges, and nucleonic fluid density measurement. Five papers on applications deal with the Ferranti and E.M.I. systems of machine tool control, control in the manufacture of steel strip, and automatic inspection. (ed. by A. D. Booth. Toronto, Butterworth, 1960. 226 p., $8.50.)

*THERMAL ENGINEERING.

This book is designed to serve as a supplement to thermodynamic texts which give inadequate reference to the equipment used for the generation of power, and refrigeration. It describes principles of construction, operation, and performance of the major components of a thermal power-generating system, emphasizing application of the energy and material balances, and presenting a balanced treatment of fossil and nuclear fuels as sources of energy, the reactions by which energy is released in them, and the manner in which part of this energy is converted into work. The book

includes chapters on power-plant cycles, steam generation and heat transfer, heat exchangers, turbines, pumps, fans, blowers and compressors. (H. L. Solberg. New York, Wiley, 1960. 649 p., $9.50.)

*HIGHWAY AND AIRPORT ENGINEERING.

Three quarters of the book deal with the historical development, planning, construction, and utilization of airports and highways, including a brief discussion of Federal-Aid, toll and bond financing, specifications, contracts, geology and soil mechanics, and safety problems. Design problems discussed include location, types of surface, drainage, grades, curves, and the complications of city streets. A section on aerial surveys is included. The final chapters deal briefly with such other fields of cargo moving as waterways, railroads, pipelines, and conveyors. (A. R. Legault. Englewood Cliffs, New Jersey, Prentice-Hall, 1960. 483 p., $11.65)

*SOILS AND SOIL ENGINEERING.

Fundamentals of soil engineering are covered extensively but briefly, the first ten chapters discussing the formation, distribution, physical properties, and classification of soils, and characteristics such as permeability, consolidation, shear strength and sub-soil stresses. The final seven chapters consider applications, emphasizing those related to foundations, retaining structures, and slope stability, with limited discussion of compacting, soil stabilization, and chemcal grouting. (R. H. Karol. Englewood Cliffs, New Jersey, Prentice-Hall, 1960. 194 p., $11.65.)

*BRITAIN'S SCIENTIFIC AND TECHNOLOGICAL MANPOWER.

This book is the result of study of British official documents dealing with technological manpower and education, made under the aegis of the President's Committee on Scientists and Engineers. This mustering of British manpower and educational statistics and description of postwar development and future demands is simplified by description of the British educational system and relevant social and economic factors. Suitable American statistics have been included where possible to provide an analogy. (G. L. Payne. California, Stanford Univ. Press, 1960. 466 p., $8.50.)

*DER PRAKTISCHE STAHLBAU TRAGERBAU. 2nd. ed.

Although published as the first volume of a revised treatise on steel buildings, this work can be used independently. The author provides a detailed treatment of the design and construction of different kinds of beams, columns, and structural frameworks. There is a separate chapter on construction details and one dealing with connecting methods in steel buildings, such as bolts, rivets, and welding. (A. Gregor. Berlin, Germany, VEB Verlag Technik, 1960. 604 p., DM 44.00.)

*BASICS OF GYROSCOPES.

More in Rider's "pictured-text" series, these two volumes, intended for students and non-specialists, present an explanation of the basic principles of gyroscopes. After a discussion of the construction and physics of gyroscope operation, the author discusses the different types of commercial gyroscopes, and their use as stabilizers, as used in equipment commonly bound to the earth's surface. Changes in design and construction required for uses in space vehicles, missiles, etc., are also considered. (Carl Machover. New York, Rider, 1960. 2 vols. $6.60.)

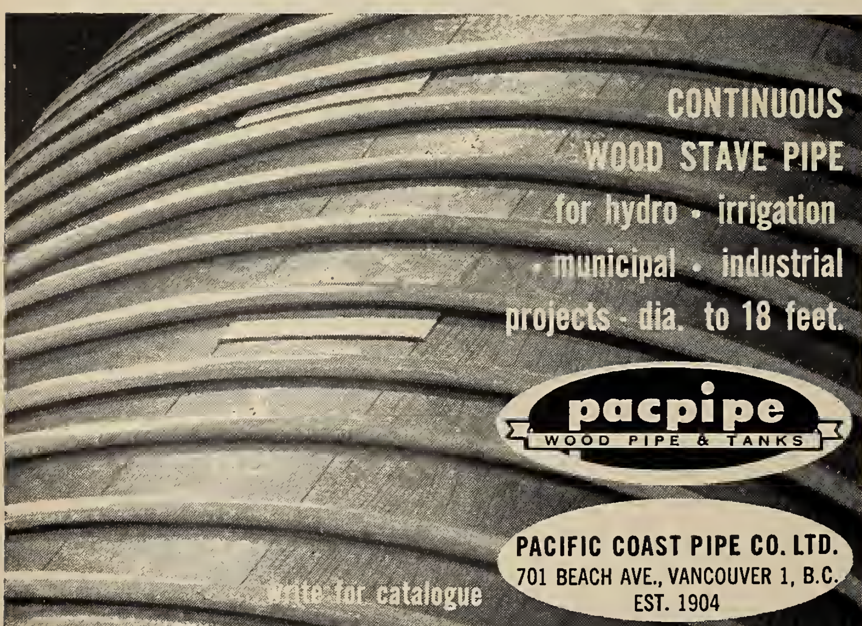
*ORTSFESTE DIESELMOTOREN UND SCHIFFSDIESELMOTOREN, 3d. ed.

The new edition of this extensive German study on stationary and marine Diesel engines retains the detailed treatment of component parts, the descriptions of currently available engines, etc., of the previous editions. There are new chapters on supercharged 4-stroke engines and on the supercharging of 2-stroke engines. Attention also is paid to the increasing importance of heavy oil engines and of the Diesel gas system as well as to the ever-growing request for ready reference formulas. (F. Mayr. Vienna, Austria, Springer-Verlag, 1960. 471 p., $32.55.)

*ELECTRONIC PROCESSES IN SOLIDS.

This monograph is an extension and

(Continued on page 200)



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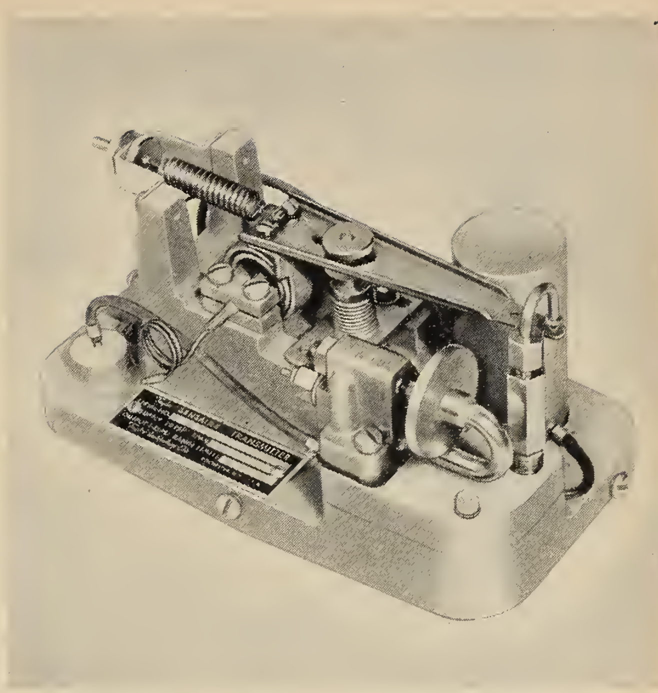

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• LIBRARY NOTES

modification of 8 lectures presenting the physical background of electric conduction phenomena in crystals, originally given in 1957 at MIT by visiting Webster Professor (E.E.) P. R. Aigrain. A fair background in calculus and elementary wave mechanics is needed. The fifteen short sections study the motion of electrons without and with an applied field, formulation and solution of the electronic wave equation, conduction theory and phenomena, transport theory, statistical mechanics of electrons in solids, and phonon and nonintrinsic scattering of electrons. (P. R. Aigrain. New York, Wiley, 1960. 67 p., $4.00.)

*SYMPOSIUM ON EFFECT OF WATER-REDUCING ADMIXTURES AND SET-RETARDING ADMIXTURES ON PROPERTIES OF CONCRETE.

Initiated to promote increased understanding of concreting materials and the best manner of combining them to produce the maximum in strength and durability, this symposium consisted of ten papers and a summary, published herein. Topics discussed include effects of admixtures on plastic, hardened, ready-mixed, structural and lean-mass concrete; the uses, specifications for and research objectives in admixtures; admixtures and Portland cement pastes and composition; definition of and functional differences between admixtures; testing and use of water-reduction retarders; and detection of lignosulfonate retarder in cement suspensions and paste. (Philadelphia, American Society for Testing Materials, 1960. 246 p., $7.50.)

*ENGINEERING ECONOMY.

To present engineering economy within the larger context of the analysis of management decisions, this book devotes the first nine chapters to "nearly all the ideas . . . traditionally included in Engineering Economy." These include managerial economics, taxes and replacement policy, and engineering decisions, covering fundamentals, the obtaining of alternatives, sources of information, production and judgment, and evaluating intangibles. The remainder of the book introduces ideas from operations research, management science, and decision theory, including probability and game theory, decisions under risk, under uncertainty, and under pressure, policies of inventory, bidding and purchasing, statistics, diversification, simulated decision making, and the economics of automation. (W. T. Morris. Homewood, Illinois, Richard D. Irwin, Inc., 1960. 506 p., $10.50.)

*THEORY OF THERMAL STRESSES.

The author first develops the fundamentals of thermoelasticity, working from the thermodynamic foundations to various alternate formulations and problem solution methods. Three chapters then discuss the physical basis of heat transfer theory and methods of solution of heat conduction boundary-value problems. Part three of the book then covers practical aspects of thermal stress analysis, mainly from the strength-of-materials viewpoint. The final section describes the manner in which temperature effects can be included in elasticity theory, covering the general nature of the idealizations used in this field, problems utilizing these idealizations, and problems involving plastic flow. (B. A. Boley and J. H. Weiner. New York, Wiley, 1960. 586 p., $15.50.)

*ADVANCES IN COMPUTERS, Volume 1.

This volume is the first in a series intended to survey progress in computer programming at frequent intervals and to present the information to others than specialists in the field. The six papers contained here are on methods of programming for business, scientific, and lingual applications. Automatic translation of languages, machine recognition of spoken words, programming for games, numerical weather predictions, general business applications, and binary

(Continued on page 207)

75th Annual General and Professional Meeting
Vancouver, B.C.
May 31 - June 2, 1961

shell and tube exchangers and related engineered products. Following completion of company training course successful applicants will be assigned to Hamilton and Montreal Branch Sales Offices. Attractive starting salary and wide range of company welfare benefits. Send complete resume and salary requirements to File No. 6923-V.

SALES ENGINEER. The company a well known manufacturer of centrifugal pumps with head office in Toronto requires requires recent graduates for its Montreal and Toronto Sales Offices. After a short training period the successful candidates will be engaged in outside sales work, calling on refineries, chemical plants, major contractors, consulting engineers and pulp and paper industry. Reply, giving full particulars to File No. 7001-V.

ASSISTANT PROFESSOR required for teaching and research in hydraulics and fluid mechanics. Salary $6000 to $8000 depending on qualifications. Please submit full details with application to President, Nova Scotia Technical College, Halifax, Nova Scotia. File No. 7072-V.

CHEMICAL AND MECHANICAL ENGINEERS. For design work for chemical plant in Montreal East. Some experience desirable. Phone or write: Mr. F. S. Runnar, B.A. Shawinigan Limited, P.O. Box 338, Montreal, Quebec. Mission 5-9203. File No. 7111-V.

SALES ENGINEER required by Canadian manufacturer of control equipment for heating, cooling and airconditioning fields. Quality products for oil, gas and electric heating. Location Montreal, bilingual preferred. Please submit full details, age, experience, education and salary. File No. 7124-V.

ELECTRICAL OR MECHANICAL ENGINEER required by Canadian manufacturer of automatic control equipment. To work with small engineering group in design, development and application. Location Toronto area. Please submit full details giving age, experience, education and salary. File No. 7125-V.

SALES ENGINEERS. With B.Sc., Mechanical or Chemical required by fully integrated major oil company, marketing department, for early assignment in Western Canada. If you believe SALES is a true engineering function, then your future professional life can fit this position. Training course given. Excellent remuneration and advancement prospects. Three to five years sales experience desirable but not a requirement. Knowledge of modern industrial equipment a definite asset. Permanent position. Full company benefits. Please give personal history and statistics. File No. 7128-V.

TRANS-CANADA AIR LINES requires an engineer with a University Degree in Mechanical, Electrical, Industrial Engineering or Engineering Physics. Employment will be in the Overhaul Research Services Group of the Winnipeg Maintenance and Overhaul Department. Duties: to carry out technical investigation on aircraft and associated equipment. Requirements: failure investigation, experience in aircraft or Power-plant Overhaul plus experience or keen interest in developing and applying statistical research methods. Industrial Engineering experience an asset. Salary range $5700 to $6700 per annum. Starting rate commensurate with qualifications. Full complement of employee benefits. File No. 7129-V.

• LIBRARY NOTES

(Continued from page 200)

arithmetic useful in designing computing equipment, are the specific topics covered. (F. L. Alt, ed. New York, Academic Press, 1960. 316 p., $10.00.)

***ASTM MANUAL FOR RATING MOTOR FUELS BY MOTOR AND RESEARCH METHODS. FOURTH EDITION.**

This revision brings up to date both the motor and research methods of testing for knock characteristics below 100 octane number and presents a new research method for above 100. Six appendices give technical data on the installation, operation, and maintenance of knock testing equipment. (Philadelphia, American Society for Testing Materials, 1960. 196 p., $7.50.)

***ELECTRICAL SYSTEMS DESIGN, 2nd. ed.**

This second edition includes a wider variety of design details, illustrated and analysed in terms of modern design standards and the National Electrical code. It covers residential wiring, selection and layout of lighting equipment, application of electric heating and air conditioning, and design of signal and communication circuits and layouts as well as preparaton of plans and specifications in the design of total electrical systems for industrial, commercial and institutional buildings. (J. F. McPartland. Toronto, McGraw-Hill, 1960. 208 p., $8.95.)

***WINDSCALE.**

Intended mainly for civil engineers, this book provides a background for all who are interested in nuclear power station engineering and construction by describing the building of the Windscale Works in England. The choice and preparation of a site, and the construction of the pile chimneys and of the effluent pipelines is related. The author then describes the remedial operation for the biological shields of the piles, and the problem of supplying supplementary cooling air to the piles, and finally recounts some of the day-to-day maintenance problems of the reactors. (S. Sinclair. London, Eng., George Newnes, 1960. 136 p., 25/-.)

***STATICS OF SOIL MEDIA.**

This translation of the second edition of Sokolovski's work includes certain revisions and amendments especially provided by the author. The theory of critical equilibrium is discussed in detail in relation to a soil medium, an ideal granular wedge, and an ideal cohesive medium (without internal friction). Applications of the theory are demonstrated in chapters on stability of foundations, slopes, and layered media, and on the pressure of a fill against retaining walls. (V. V. Sokolovski. Toronto, Butterworth, 1960. 237 p., $10.50.)

***ELEMENTARY THEORETICAL FLUID MECHANICS.**

Here the fundamentals of fluid mechanics are developed with a minimum of attention to practical applications in order to provide a basis for the study of applications in many fields of advanced specialization. The author adheres to the basic equations almost exclusively to promote versatility in the fundamentals and avoid formula dependence. The text covers fluid statistics, conservation of matter and of energy, momentum, friction, dimensional analysis and potential flow. Brief treatments of acoustic velocity, cavitation, thermodynamics, and boundary layer theory are presented in appendices. (K. Brenkert. New York, Wiley, 1960. 348 p., $7.50.)


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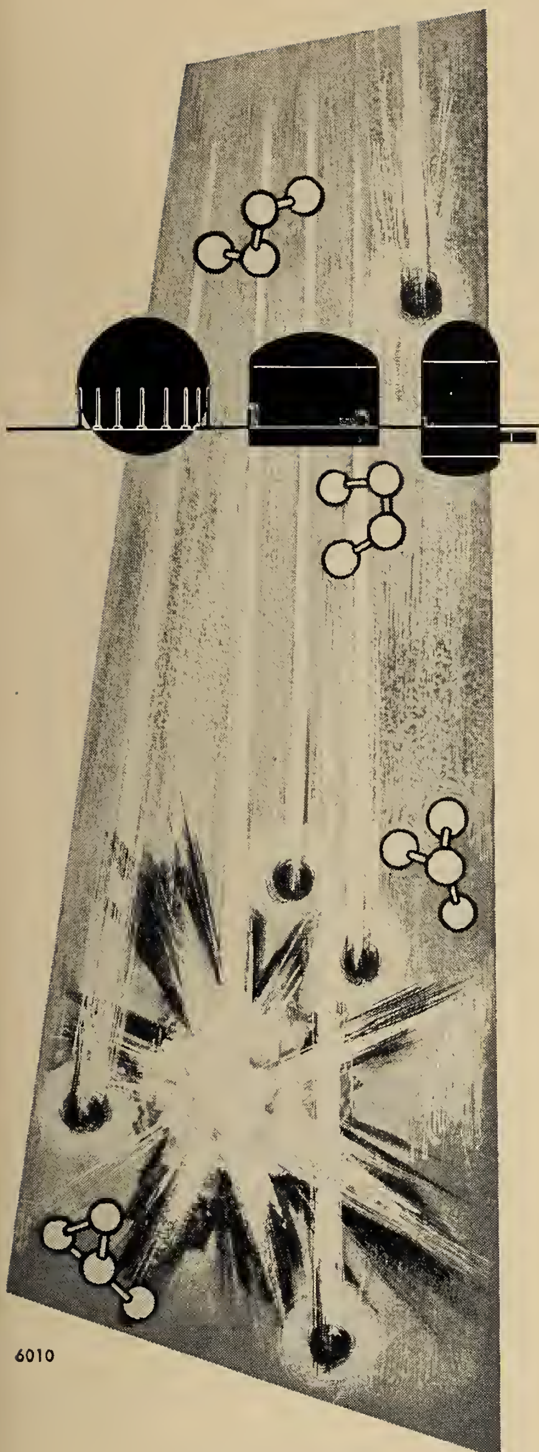
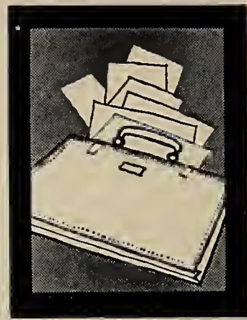


Business and Industrial Briefs



Appointments and Transfers

D. L. George Turvey has been promoted to general sales manager for Armco Drainage and Metal Products of Canada Limited, Guelph, Ont. Replacing Mr. Turvey as Ontario sales manager is **John E. Wilson.**

John W. Ames, chief design engineer—commercial, of Avro Aircraft Limited has been appointed vice-president and general manager of Canadian Applied Research Limited. CARL is a member of the Aeronautical Group of A. V. Roe Canada Limited and is engaged principally in the design, development and manufacture of airborne navigation equipment.

Evan S. Beal has succeeded **Kenneth C. Blackwell** as technical sales representative for petroleum chemicals in Ontario for Du Pont of Canada Limited. Mr. Blackwell has moved to Calgary as technical sales representative for petroleum chemicals there.

Dr. George B. Langford of Toronto was selected Canada's official observer to the Conference of Engineering Societies of Western Europe and the U.S.A. in Brussels. Dr. Langford heads the Department of Geological Sciences at University of Toronto.

Walter Stensch has been appointed chief engineer of the structural deparment of Surveyer, Nenniger and Chenevert, consulting engineers, of Montreal.

Scott W. Hill has been appointed Industrial Products Department representative for Sun Oil Company Limited.

H. J. Lang assumed his duties as president of Canada Iron Foundries, Limited, Montreal, September 1. Formerly he was president of National Steel Car Corporation Limited.

W. R. Clerihue has been appointed Treasurer and Controller of Dominion Structural Steel Limited. Previously Mr. Clerihue had been Controller of Canada Iron Foundries, Limited, and director and Treasurer of Peacock Bros., Limited.

Ronald J. Cooksley, former Ontario Government Industrial Commissioner in Chicago, has been appointed director of industrial development for the Township of Trafalgar.

Duart A. MacLean has been named a Principal and Director of R. C. Thurber and Associates Limited, consulting engineers, Victoria.

Anthony H. Cardwell and **Douglas H. Peacock** have been promoted to top Canadian sales posts by Burroughs Adding Machine of Canada Limited. Mr. Cardwell has been appointed general products sales manager and Mr. Peacock has been named sales manager—computer products.

George E. Temple has been appointed vice-president of Dominion Structural Steel Limited. Mr. Temple formerly was vice-president and general manager of Catalytic Construction of Canada, Limited.

Developments

LOCAL DISTRIBUTION systems in sections of Chambly and Laprairie counties in Quebec which were owned by Shawinigan Water and Power Company, have been purchased by Quebec Hydro. Purpose of the transaction was to prevent duplication of lines and equipment and to effect a consolidation of distribution by Quebec Hydro in the metropolitan area it serves.

INCREASED half-year earning have been reported in an interim report of The Canadian International Nickel Company of Canada, Limited and subsidiaries. For the period ended June 30, 1960, the company showed earnings of $1.50 a share compared with $1.31 a share in the first six months of 1959. Second-quarter earnings of 65c a share compared with first-quarter earnings of 85c and earnings during the second quarter of last year of 73c.

BENEFITS of mechanical demand registers are outlined in a new four-page bulletin distributed by Canadian General Electric Company of Toronto. Bulletin 5146 describes the company's M-30 Demand Register, which when used with either single phase or poly phase GE Watthour Meters, converts them into demand meters.

PARA-FLEX COUPLINGS, manufactured by United Steel Corporation Limited, are designed for high-speed, high-torque and flywheel applications. They feature a pan-shaped rubber flexing element of new design. Designed for speed up to 5,230 r.p.m. the unit may be used with electric motors or internal combustion engines to operate such equipment as hammer mills, compressors, pumps, fans, marine drives, and blowers.

SIX CONE ROOF STORAGE TANKS, each with a capacity of 80,000 bbl., are being built at Fort William, Ont., for Canadian Husky Oil and Refining Limited. The manufacturer is Sparling Tank and Manufacturing Company, a division of Products Tank Line of Canada, Limited. New construction and alterations at Husky's Lakehead refinery will total $1 million this year, about half of which will be spent on storage facilities.

A NEW STRUCTURAL STEEL has been manufactured by the Steel Company of Canada, Limited. Identified under the A.S.T.M. Designation A 36, the new steel is described by the company as having a "cost-to-strength ratio substantially better than for existing carbon structural steel specifications". A 36 specification covers carbon steel shapes, plates and bars of structural quality not over 4 in. in thickness for use in the construction or bridges and buildings and for general structural use.

CONSOLIDATED EARNINGS of the Shawinigan Water and Power Company, St. Maurice Power Corporation, and Southern Canada Power Companv, for the first six months of 1960 applicable to Shawinigan common shares were 80c a share. On 7,826,956 shares outstanding June 30 earnings totalled $6,267,553. The half-year earnings last year totalled $5,408,574, or 70 cents on each of 7,638,383 shares outstanding.

CORROSION PROBLEMS affecting outdoor switchgear housing have been attacked by Canadian Allis-Chalmers Limited. The company has introduced an entire housing for ac. switchgear

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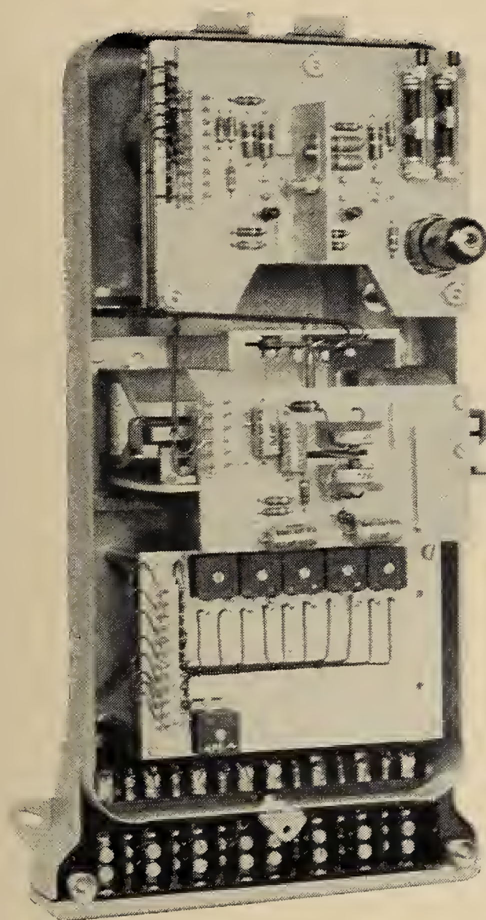
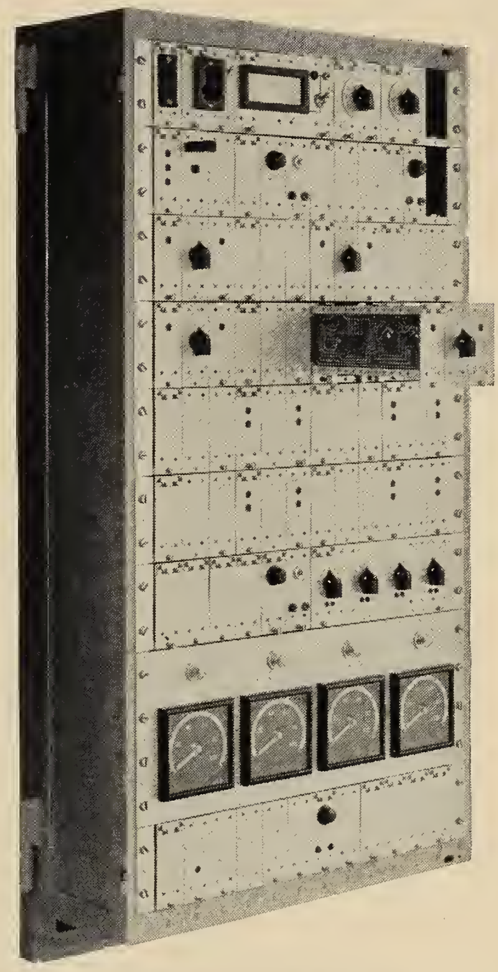


Transistorized torque balance transmitter



Transistorized channelling equipment

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made of extruded aluminum panels. Aluminum extrusions are snapped together to form a maintenance-free structure for outdoor use. It is called the Aluma-Clad switchgear housing, and requires no paint to protect it against weather.

PRESSURE, VACUUM AND MAGNETIC GUAGES are discussed in two new catalogues available from Peacock Brothers Limited of Montreal. Catalogue PB-065 contains detailed information concerning standard phosphor bronze, steel, stainless steel and K Monel Bourdon tube guages and on Schaffer diaphragm type guages. Catalogue 388 describes magnetic guages produced by Jerguson Gage and Valve Company.

POWER, traced from the first pulse of generation to the moment when appliances are plugged in, was featured in a display at the Canadian National Exhibition. In one of the most comprehensive exhibits ever produced by the Hydro-Electric Power Commission of Ontario, new horizons in the field of electricity were outlined graphically by models, maps and murals along with a full-size home.

OFFICES AND WAREHOUSE will be contained in a new building being erected for Canadian General Electric Company Limited in Lancaster, N.B. The first sod was turned this summer and it is scheduled for occupancy in January. The building will contain 5,000 sq. ft. of office space and 14,600 sq. ft. for warehouse and services.

IRON CLAD CONCRETE FLOORS have shown to ability to outlast by a wide margin floors made of ordinary concrete. A description of a Masterplate floor is contained in a bulletin prepared by the Master Builders Company, Limited, Toronto. The floor has an armoured surface about ⅛ in. thick. This is produced by dusting a dry mixture of Masterplate and cement on the surface of freshly-coated concrete.

A COPPER PRICE CHANGE has been announced by The International Nickel Company of Canada, Limited. The new domestic copper price, effective August 30, is 30 cents Canadian per pound delivered Toronto.

R-27 SILICONE, a Union Carbide product for above-grade masonry water repellents is described in a new brochure from the company's Bakelite Division. The brochure is designed to answer questions regarding performance, meeting of specifications, effectiveness and applications of water repellents made with the product.

320 ACRES HAVE BEEN OPENED by Vancouver's Skeena St. Pumping Station since it was built in 1954. Lowlying sections of the Grandview Highway have been pumped and made available for industrial and residential use.

COMMERCIAL WOOD PRESERVATIVES have been subjected to a 14-year test by the United States Department of Agriculture. In plots in varying climatic conditions around the world, stakes were driven. Some were untreated while others were dip-treated or pressure treated with various preservatives. Untreated stakes that would have lasted about six years at Chalk River, Ont., were destroyed in one year in a more humid climate. Stakes dipped in creosote lasted one to four years longer than untreated stakes, depending upon the climate of the test plot.

A NEW CHEMICAL ENGINEERING BUILDING at University of British Columbia is expected to be ready in September, 1961. Anglin-Norcross (Western) Limited, has been awarded a contract for $608,637 for construction of the three-storey building. It will contain 30,000 sq. ft. of space and will cost $750,000. The structure is the first of six to be built on a 15-acre site at the south end of the campus for the faculty of applied science.

PAINLESS DENTISTRY has contributed a miniature cutting tool to industry. An industrial version of the Borden Airotor used for painless dentistry now is available for precision miniature machining. With a rotating speed of 300,000 r.p.m., and using carbide or diamond point burs, it is possible to machine materials with a hardness factor of 62 Rockewell 'C' 90% faster than with conventional equipment.

TECHNICAL ADVICE to architects, consulting engineers and to the construction industry will be provided at the newly-established Ontario Bureau for Lathing and Plastering. The service is being provided by the Contracting, Lathing and Plastering Association of Ontario, Incorporated in co-operation with the Inter-Provincial Council of Lathers.

BOWATER PAPER CORPORATION LIMITED and its subsidiaries, in an interim financial statement, report a gross profit equivalent to $30,766,000 for the first half of 1960. This compares with a gross profit of $25,385,000 for the six months ended June 30, 1959. An interim dividend of about 14c a share was declared.

TWO HUGE VACUUM TANK CARS have been ordered by Canadian Liquid Air Company. The cars will be nearly twice the length of standard cars and will have an 80% greater capacity. They are 64 ft., 4¼ in. long and have a capacity of 13,700 Imp. gal. The cars are being built by Union Tank Car Company and will be used to transport liquid oxygen and other liquefied atmospheric gases.

GREATER FUEL ECONOMY with high-displacement diesel engines has been attained through co-ordinated research and testing by the White Motor Company and Cummins Engine Company, Incorporated. President Norman H. Bell of the White Company reports the program has resulted in White chassis and Cummins engine modifications that produce 7.3% to 18.5% more miles per gallon than other leading large-displacement engines.

EASTERN AND WESTERN DIVISIONS have been established by Boyles Bros. Drilling Company, Limited. The Eastern Division under the management of Don Mackay will include Boyles Bros. Drilling (Eastern) Limited at Port Arthur, Boyles Bros. (Quebec) Limited at Noranda, Boyles Bros. (Maritime) Limited, at Moncton, N.B., and the newly-formed sales division at Toronto. The Western Division, under the management of Reg McWilliams will include Boyles Bros. Drilling Company, Limited, at Vancouver.

GROWING MARKET DEMAND for marine gas and diesel engines has caused Cooper-Bessemer of Canada, Limited, to reopen its Halifax warehouse. Depressed market conditions caused the company to relocate the warehouse in Gloucester, Mass., but subsequent market expansions have created a permanent need for facilities in Halifax. A company statement said the Halifax facility is anticipated eventually to house gas and diesel engines produced at the company's newly-leased manufacturing facilities at Stratford, Ont.

LARGEST POWER SIZES ever offered by John Deere and Company are included in a new line of tractors and equipment it has developed for earth-moving, logging, landscaping and material handling.

A 51-MILE PIPE LINE extension from Winnipeg south to the international border near Emerson, Man., has been completed by Trans-Canada Pipe Lines Limited. Canadian natural gas now is moving to the United States for purging and testing sections of the Midwestern Gas Transmission lines now under construction from the border to Marshfield, Wis. The American line is scheduled to be finished this autumn.

NATURAL GAS now is being used by Falconbridge Nickel Mines Limited. The 6½ miles of 6 in. pipeline was completed, purged and tested July 14 and use of natural gas began the following month. Initially, Falconbridge will use a maximum of 2 million cu. ft. of gas a day to fire two boilers, each with a capacity of 25,000 lb. of steam an hour, and five sintering machines used in the smelting process.

(More Briefs on page 216)

• MORE BRIEFS

A NEW-TYPE POWER TAKEOFF UNIT that can deliver 70 hp. without requiring changes in other power train components has gone into production at the Automotive Division of Canadian Clark Limited. Designated the P-200 Flywheel Power Takeoff, the new design bolts to the engine flywheel housing, thus is ahead and independent of the clutch and transmission. Primary applications are vehicles such as transit concrete mixers, fire trucks, fuel trucks and farm equipment where large amounts of engine power are required to drive accessories.

OUTSTANDING SALES AND EARNINGS for the fiscal year ended June 30, 1960 have been reported by Beckman Instruments, Incorporated. Sales totalled $54,257,282 compared with $44,872,768 in 1959. Net income per share was $2.24 compared with $1.30.

T. McAVITY AND SONS LIMITED valve manufacturers of Saint John, N.B., has been purchased by Crane Limited. The price was not disclosed. McAvity currently employs about 500 workers in its plants at Saint John and Medicine Hat, Alta. Annual sales exceed $5 million.

SIDEWALK SUPERINTENDENTS in Montreal have been treated to a comprehensive view of a major construction project by means of closed-circuit television. At the construction site of the new CIL House, 90-minute shows were presented each lunch hour. The camera was perched on the 14th floor of the steel framework and four receivers were set up in a public gallery above the sidewalk. The system was to operate for two weeks, with a possibility it may be re-established when the steelwork reaches the final storey — the 34th.

MERGER OF TWO BRITISH FIRMS has been approved by shareholders of the companies. Davy-United Limited and The Power-Gas Corporaton Limited will merge under the title Davy-Ashmore Limited. The Davy-United Group is the largest manufacturing unit in the United Kingdom for the design and production of rolling mills and auxiliary equipment for the steel and non-ferrous industries. The Power-Gas Group, which includes Ashmore, Benson, Pease and Company, Limited, P.G. Engineering Limited and Rose, Downs and Thompson Limited, specializes in the design, manufacture and erection of plants for the iron and steel, chemical, gas, oil, petro-chemical, fatty oil and fish meal industries. The new group controls 11 operating subsidiaries. The Canadian subsidiary is Power-Gas Canada Limited in Montreal.

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● MORE BRIEFS

THE ECONOMICS OF GAS TURBINE GENERATION for United States Defence sites and for commercial applications are discussed in a booklet issued recently by Clark Bros. Co., one of the Dresser Industries. A comparative analysis of gas turbine, steam and diesel generating plants is made. Major factors such as installed cost, fuel, operating cost and the time value of money are reviewed through the use of text, charts and graphs.

PREPARING A SPECIFICATION for a Universal Air Data System to be used by all airlines was the assignment given the Air Data System Sub-Committee of the Airlines Electronic Engineering Committee, Aeronautical Radio, Inc. The objective of the specification is to define a central air data system that will provide the required air data parameters for contemporary and future high performance jet transport aircraft. Basis of the system will be a computer which must be adaptable without modification to any of these aircraft and will provide information for cockpit display, flight control use and/or use in other aircraft control systems.

REINFORCED ASPHALTIC CONCRETE HIGHWAY resurfacing has been subjected to a completely controlled experimental field installation. The project was the improvement of a 1½ mile stretch of highway in New York State. Although the existing pcc pavement was generally in passable condition several of its 40 ft. slabs had fairly severe transverse or corner cracks. Because of this and the need to widen the road it was decided to make a test installation of wire fabric reinforced asphaltic concrete resurfacing. The previous condition of the road was recorded carefully on film and by a slab-by-slab crack survey and will be compared with its future condition.

PREVENTION AND CONTROL of Corrosion in industry are outlined in a new manual published for Scientific Surveys Limited, Consultants and Technical publishers, London, England.

DAVIE SHIPBUILDING WINS AD CERTIFICATE

Davie Shipbuilding Ltd. has been awarded an E.I.C. Certificate of Advertising Merit for their two colour, full page, advertisement which appeared on page four of the July 1960 issue. The advertisement is very striking in appearance and the "teaser heading" induces reading of the copy.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Fifty readers of the "Journal" — representative of all provinces — selected the Davie Shipbuilding Limited advertisement as the best in the July issue from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

The advertisement appears on page four of the issue. It is headed: "GIANT CAMERA FOR OUTER SPACE? NO, BUT . . ." The copy explains that the structure illustrating the advertisement is a double hopper mill feed bin — "no more than a routine construction job for DAVIESHIP".

The advertisement was prepared and placed by Cockfield, Brown & Co. Ltd., Montreal, Ross M. Mackay, Account Executive. The Company official responsible for advertising is J. G. Fisher of Canada Steamship Lines of which Davie Shipbuilding is a subsidiary.

TWENTY-ONE SENIOR ENGINEERS of H. G. Acres and Company, Limited, Niagara Falls, have pooled their resources and bought back shares of the company held by a United States firm. Through their acction H. G. Acres has reverted to 100% Canadian control. The shares were held by Fluor Corporation of Canada, Limited, wholly-owned subsidiary of the Fluor Corporation of Los Angeles.

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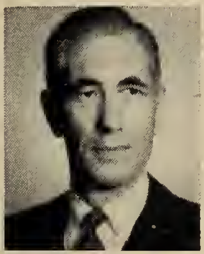

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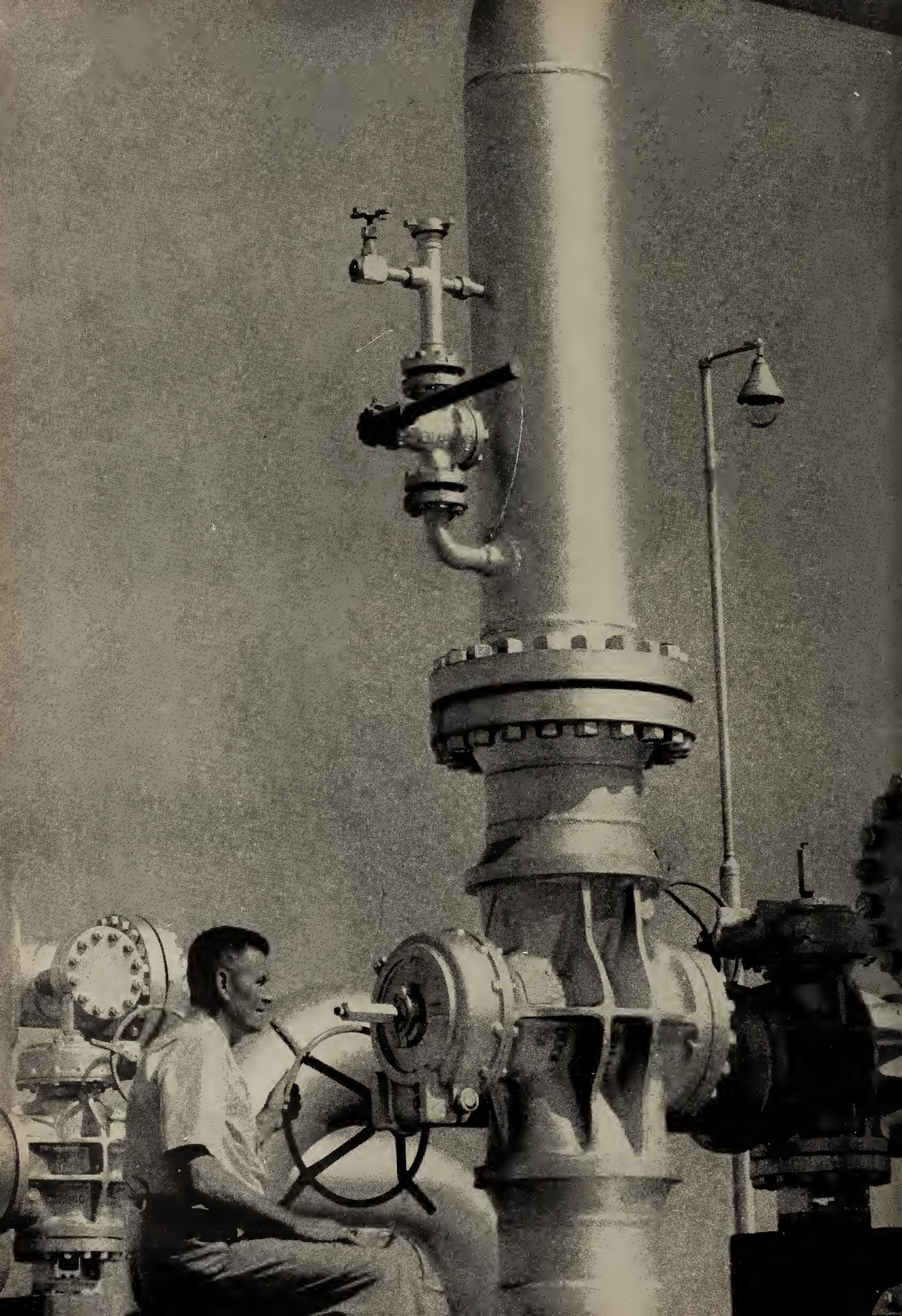
COVER ILLUSTRATION

The gap in this bridge is being closed with a 10 ton bottom chord section for the last panel of the suspension span. (Photo courtesy Dominion Bridge Company Limited).



THE WARSAK HYDRO-ELECTRIC AND IRRIGATION PROJECT

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

The government of Canada decided in 1955 that their major Colombo Plan Project for the nex few years would be the Warsak multi-purpose development. Previous investigation had established the need for low cost electrical power in the area to aid in the setting up of industries and for deep-well pumping for land improvement, as well as for additional irrigation of the nearby plain. The Warsak development could make a major contribution to these requirements, and in the course of construction a great many Pakistanis could be trained in modern construction methods and later continue to develop their own country. Negotiations were carried out between the Governments of Pakistan and Canada to formulate the contribution that each would make, and the general contract awarded in June 1955.

IN GENERAL it was agreed that Canada would pay the cost of supervisors, technicians, material and equipment that had to be brought into the country, and that Pakistan would pay all rupee costs for labour, for such material as could be produced in Pakistan, for electric power and fuel during construction, and for housing and accommodation. The latter costs were to be paid from counterpart funds from the sale of wheat donated by Canada.

General Description

Warsak is the name of a small village where the Kabul River leaves a deep narrow gorge in the Hindu Kush range to flow across the plain, thence to join the Indus River. It is situated at lat. 34° N, long. 71° E, and the general ground level of the surrounding plain is 1100 ft. above sea level. Climate is subtropical, with temperature ranging from the thirties in the Winter, to as high as 130° F. in the Summer. Rainfall is light, 16 in./yr., and the immediate area is little affected by the monsoon.

The Kabul River has its source in the mountains of Afghanistan, with little storage, and flow ranges from a recorded minimum of 4,180 c.f.s., to a probable maximum of 225,000 c.f.s. Fortunately, the period of low flow corresponds to the best weather for working, and although the work was carried on throughout the year, it was possible to concentrate in the river bottom during the months of September to April. (See Fig. 3).

The permanent work (see Fig. 1.) consists of a gravity type dam 650 ft. long and a maximum height of 270 ft., comprising an overflow section 440 ft. long controlled by nine 40 ft. wide taintor gates between 10 ft. wide piers. A bulkhead extends into the sides of the gorge at each end. Below the dam is a stilling basin designed to dissipate the energy of the water during periods of overflow. A power tunnel in the South bank of the river 39 ft. diam., concrete lined, and 700 ft. long leads the water to a manifold from which six 18 ft. diam. steel lined penstock tunnels take the water to the turbines. The power house is built into the wall of the gorge and the water discharges into a tailrace channel with an outlet just below the stilling basin. Ultimate installation provides for six 55,000 hp. units of which four are now being installed. Auxiliary power is supplied by two 750 kva. house units fed by one 6 ft. diam. penstock tunnel.

An irrigation tunnel 3½ miles long

and 10 ft. diam. inside the concrete lining leads water to a nearby portion of the arid plain to irrigate 100,000 acres of land.

Temporary diversion was achieved by means of a 35 ft. diam. concrete lined tunnel 1,700 ft. long in the North bank which by-passed the cofferdams. The capacity of this tunnel was approximately 30,000 c.f.s. with water at the level of the upstream cofferdam, thereby providing diversion for about 6½ to 7 months per year.

Communications

A broad gauge (66 in.) railroad runs about 1,000 miles from Karachi, the main seaport, to Jamrud Fort, the Pakistan entrance to the famous Khyber Pass. A 15 mile hard top road was built from there to Warsak, over which all equipment and material had to be trucked.

The nearest airport is 19 miles distant at Peshawar, an ancient city with a present population of about half a million. The Pakistan Government Airline flies from Karachi to Peshawar 4 or 5 times a week, via Lahore and Rawalpindi, carrying air freight and mail as well as passengers.

There is a fairly good road from Peshawar to Lahore, but from Lahore to Karachi road travel is difficult, and the passenger train service between Peshawar and Karachi is poor. Telephone, telegraph and air-mail services to Karachi are fair.

Shipments from Montreal, New York or Saint John take from 30 to 35 days, a ship leaving about once a month. Transfer at Karachi to railroad cars, passage through customs, and inland freight to Jamrud averaged about 3 weeks. It will be readily seen that from the time an article was requisitioned at the site, until delivery could be expected, 3 months elapsed provided there was no particular delay by the manufacturer. Air freight had to be used sparingly due to cost, and careful planning kept this expense down to a total of about $40,000. Air-mail takes about 6 days from Canada, and cable service is good.

Local Facilities

Most of the ordinary materials required for construction are in short supply in Pakistan and local purchases were of small volume. Although most foodstuffs are available, a lot of them are of indifferent quality by Canadian standards, and a considerable quantity of food was imported. Approximately half of the diet of Canadian personnel was from local sources.

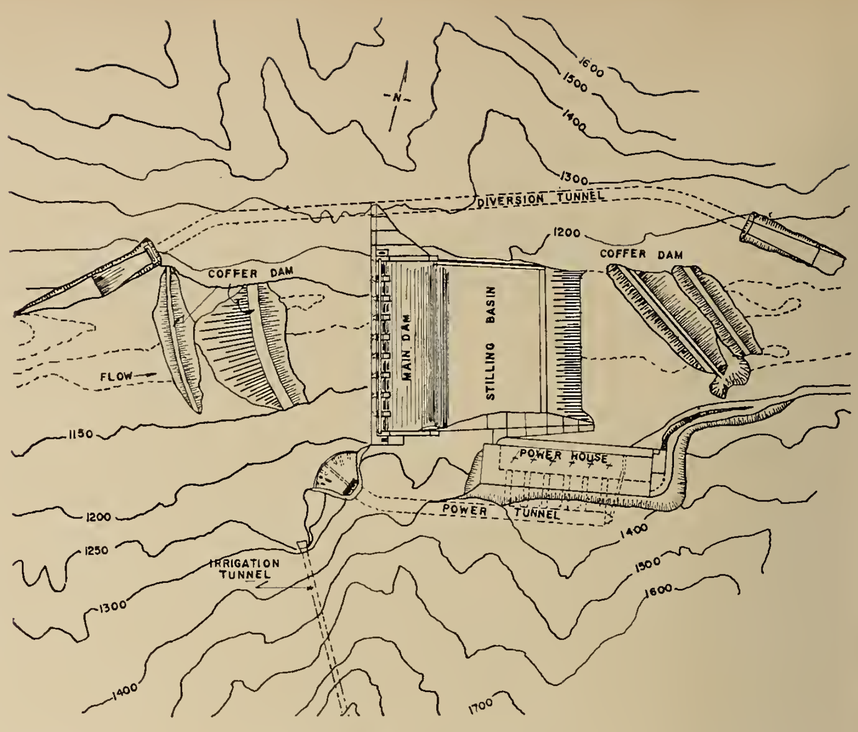


Fig. 1. General Layout of Project

Sand and gravel deposits for concrete aggregate were found within a few miles of the dam, close to the Kabul River. Processing plants were designed to suit conditions, and all aggregates were obtained from crushing, screening and washing. The following quantities were handled:—

Stripping	750,000 cu. yd.
Processing	1,500,000 cu. yd.
Production	1,100,000 cu. yd.

Cement was obtained from a plant at Wah, some 90 miles distant by rail. A consistently good grade of Portland cement was maintained, and during the busy period as much as 19,000 tons per month was delivered, mostly in bulk, in specially built freight cars. It is worth noting that the production from the Maple Leaf Cement Plant at Daud Kehl, an earlier Canadian Colombo Plan Project, made it possible for the Wah Plant to deliver Warsak's requirements without seriously disrupting supplies to other users.

Pakistan agreed to supply 5,000 h.p. of electrical power, and found it necessary to purchase four 1,000 kw. diesel generators which were in operation by July 1956, prior to which a small quantity of local power was made available. Peak requirement was 4,560 kw., major demands being five 200 h.p. compressor motors and two 300 h.p. cableway motors. Power is at 50 cycles, low voltages being 230-400.

Local accommodation had to be constructed, for Pakistanis as well as Canadians. Married quarters were built for Canadians who brought their families, and for the senior Pakistani staff; bachelor quarters and a single men's mess were also built, and Pakistanis were quartered in multiple unit barracks. As timber is in short supply in the country, all buildings are of masonry, bricklaying being a well known trade. Mud bricks or kacha bricks are in wide use and are reasonably satisfactory, but require some maintenance in wet weather. Burnt bricks are also available though much more expensive and were mostly used for the permanent houses. Temporary accommodation was a difficult problem, very little being available, and resulted in the build-up of the Canadian staff being considerably delayed during the first 6 to 8 months. It was obviously undesirable to spend dollars on imported prefabricated houses.

Following considerable study, it was decided to supply air-conditioning for the offices, hospital, and quarters occupied by Canadians. The houses and bachelor quarters had one air-conditioning unit for each occupied bedroom.

Hospital and medical facilities are generally lacking in the East, and it was necessary to establish them based on Canadian standards. A 50 bed hospital was built, and staffed by two

Canadian doctors and nurses, as well as a number of Pakistani doctors, nurses and orderlies. It was fully equipped, and its main purpose was to treat job accidents and sickness amongst the employees and their families. Actually, many patients from other than the Warsak job have been treated, which was greatly appreciated. The training given to the Pakistani staff will be of inestimable benefit.

Preliminary Planning

A good deal of trouble was experienced in making up the construction schedule, with little knowledge of conditions to be encountered. The Canadian Government authorities were anxious to make a quick start once the decision to proceed had been taken; likewise the Pakistani authorities seemed to want to get ahead rapidly, though understandably without full knowledge of what was involved. A preliminary visit to the site revealed sufficient power was not available from the local net-work; construction of accommodation was proceeding slowly; the supply of skilled or semi-skilled men was very limited; and very few foremen could be found. Although it had been hoped the work could be carried out with only about forty Canadians, it was soon realized that more than double that number would be required.

All of these factors made planning difficult, and cost estimating particularly so. Another factor about which little was known was the output of labour, and here some rather vague assumptions had to be made. Knowledge of labour costs or the number of men required to do a certain job on similar work in Canada was of little value. Although the contractor was not expected to make a very close estimate of Pakistani costs, which as previously mentioned covered all labour costs except supervision, it was important to estimate the output and operating efficiency of construction equipment, all of which is closely linked with labour efficiency.

The important requirement of training as many Pakistanis as possible also affected labour cost considerably. It meant that there would always be a rather high percentage of only partially productive apprentices, a condition which persisted throughout the entire job. This had considerable bearing on equipment output, as it resulted in excessive mechanical breakdowns due to continual operation by inexperienced men. The rate of progress eventually attained in the diversion tunnel is an example of the results of the training program. During the last month of this work, the heading advanced 18 ft. per day, in rock that required continual arch support. This was a very creditable performance, and a result of the kind of assistance referred to by H.R.H. The Prince Philip in his address to scientists and engineers in Toronto on June 29, 1959. (*The Engineering Journal*, August 1959, p. 91).

Special Problems Encountered

The general contractor had not previously worked abroad and in fact the writer does not know of any Canadian owned contracting company having undertaken major work outside the Americas. Very few of the men sent to Warsak had ever been to the East, and most of them had not been off the North American continent. The government requirement that all employees from Canada should be Canadians was adhered to, and care was taken when approving men to choose only those who might be expected to make a favourable impression. In addition, in the case of married men, whenever possible, their wives were also interviewed to ascertain whether they were really willing to go, and if they could be expected to fit in well to their new environment.

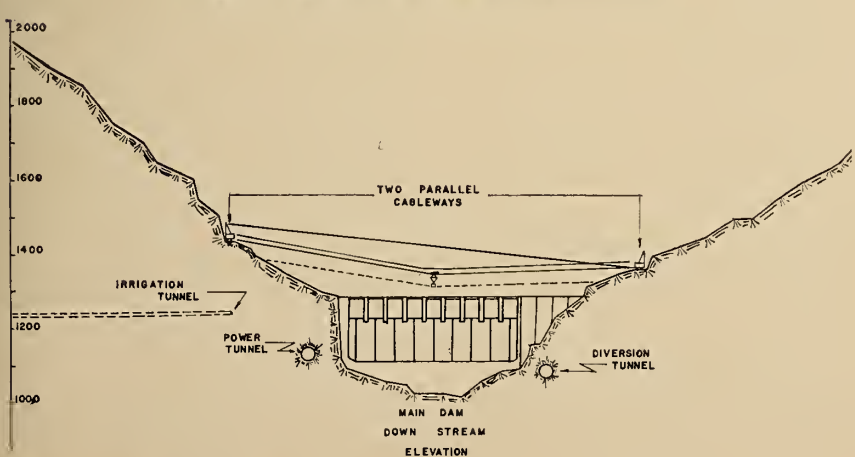
Every effort was made to explain the living and working conditions to be expected. By the nature of his work, a General Contractor has a small proportion of permanent employees available, and it was obviously necessary to recruit a number of men not in the employ of the Company, though many of them had previously worked for the Company at one time or another. The statistics in Table 2 give an indication of the results achieved by the careful

TABLE No. I

Quantities Handled

Common Excavation and Fill	*cubic yards*
Permanent structures	645,000
Diversion tunnel inlet and outlet	37,500
Cofferdams	204,000
Aggregate stripping	755,200
Aggregate processing	1,530,400
Roads	120,000
Construction plant installation	93,500
Silt removal	220,700
Miscellaneous grading	110,000
	3,716,300
Rock Excavation—Open Cut	
Permanent structures	1,199,200
Diversion tunnel inlet and outlet	170,000
Cofferdams	11,100
Roads	271,300
Construction plant installation	109,700
	1,761,300
Rock Excavation in Tunnels	*cubic yards*
Diversion tunnel	86,200
Power tunnel	47,700
Penstock tunnels	25,600
Irrigation tunnel	91,800
	251,300
Concrete	
Tunnel linings	131,000
Main dam	396,920
Stilling basin and wave wall	126,340
Power house	103,050
Power tunnel intake and silt retaining wall	39,590
Roads, bridges and colony buildings	6,700
Cofferdam revetment	18,050
Plant installation and temporary construction	22,230
	843,880
Dry masonry work, misc.	53,600

Fig. 2. Cross Section at upstream face of Dam



checking mentioned above.

It is of interest to note that of the total number of uncompleted contracts, approximately half were during the first year of operations when living conditions left much to be desired, and the contractor was gaining experience in the type of men who could be expected to fit in and work well on a foreign job and in the climatic and other conditions prevailing at Warsak.

An early decision was made to establish living conditions for Canadians reasonably similar to those to which they were accustomed at home; and to take married men and their families, when experience and suitability indicated. The results showed that this decision was justified.

A school was established with Canadian teachers to take pupils up to and including eighth grade, on the general standard of Ontario Public Schools. Special arrangements had to be made by the parents for children above eighth grade.

Full attention was paid to recreation facilities. A building was constructed for movies, dances, etc., and a swimming pool, tennis courts, bowling alleys and billiard tables followed. The Pakistani staff were encouraged to partake in all of these activities, and the benefits were many.

All employees were engaged under contract for a period of 2 yr., plus or minus three months at the discretion of the employer. Basic salary plus foreign allowance was approximately 1/3 higher than an equivalent salary in Eastern Canada, and a further sum of 15% of basic salary was set aside as an incentive bonus, payable only after successful completion of the employment contract. Three weeks annual leave was granted, and termination leave of 1 day for every 15 days of completed contract was allowed for home leave. Transportation both ways was paid for the employee and his family on the basis of first class air fare. It was felt that the above terms were sufficient to attract good men, though at times certain classifications were difficult to find, particularly during the year 1957.

Considerable space has been taken up in explaining employment conditions for the Canadians who worked at Warsak. These were the key men on a project taking over four years to complete, at a total cost of about $36,000,000 Canadian, in addition to about $25,000,000 in Pakistan rupees. Most of the senior men remained the entire period, with two vacation periods between contracts. The writer feels that an examination of the conditions encountered warrants some further space.

The years 1955-56-57 were years of relatively full employment in the construction industry in Canada, and the Canadians who went to Warsak all left good jobs, friends, homes, and associations to travel almost half way round the world to live and work amongst people of a different race, language, and culture, with whom, superficially, they had little in common.

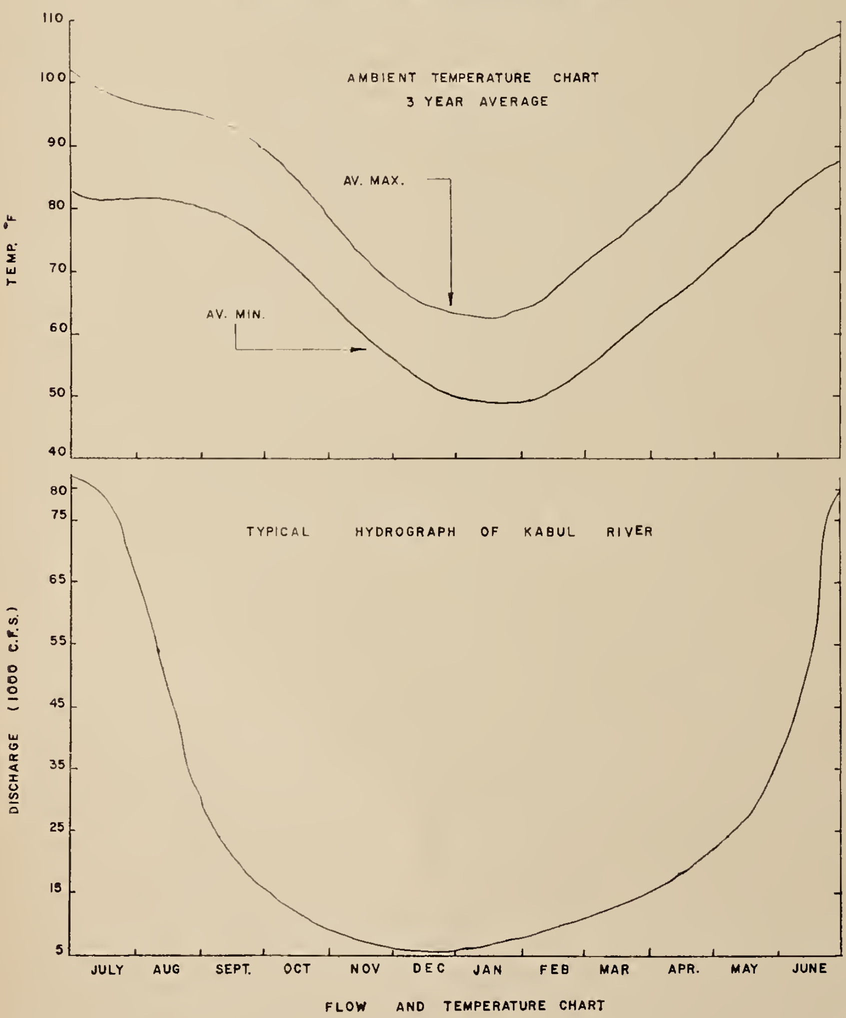
Furthermore, they were subjected to a climate which for 5 months of the year is excessively hot

TABLE No. 2

Statistical Analysis of Canadian Employment Records

	Married	*Single*	*Total*
Maximum number of employees present	—	—	147
Total employees involved	151	59	210
Still remaining January 31, 1960	—	—	96
Total contracts signed (including renewals)	—	—	309
Contracts uncompleted (all causes)	—	—	49
Contracts broken during first year	—	—	23
% Contracts uncompleted (all causes)	—	—	15.9
% Contracts uncompleted after first year	—	—	12.9
Contracts broken on account of ill health	—	—	7
Contracts broken on account of ill health in family	—	—	5
Employees discharged	2	8	10
Includes for insobriety	2	5	7
% Employees discharged	1	8.5	4.8
Employees quit	19	8	27
% Employees quit	12.6	13.5	12.9

Fig. 3. River flow and temperature chart



compared to Canada. The tribesmen from whom the great bulk of the labour force was drawn are Pathans, people who have never really known law and order as we know them. They live in what we would describe as almost abject poverty, and their very livelihood depends on the small amount of moisture which falls to yield a crop sufficient for themselves and their few animals. A slight reduction in precipitation results in a poor crop and means near starvation for many.

Patient explanation by the Pakistanis in authority gradually convinced the tribesmen in the vicinity that the completion of Warsak would bring permanent benefit to them, and an opportunity for gainful employment as well as the acquisition of a trade in the meantime. But this took time, and many frustrations were encountered particularly during the first six months or so when the Canadians sometimes wondered if they would ever be able to build up an efficient working force. As will be seen later, such a force was achieved. The method of labour recruitment was working through the Malik, who is the political chief of a village. He it is who receives and dispenses the government grant, and who administers justice of a kind. The labourer pays a small proportion of his wages, either directly or through the company to the Malik. There was seldom any lack of numbers, but especially at first it was difficult to know how many of any particular gang might turn up on the morrow. Gradually the men seemed to achieve a certain sense of responsibility towards their work, they became aware of the opportunities for advancement, and the percentage of absentees declined to less than 8%.

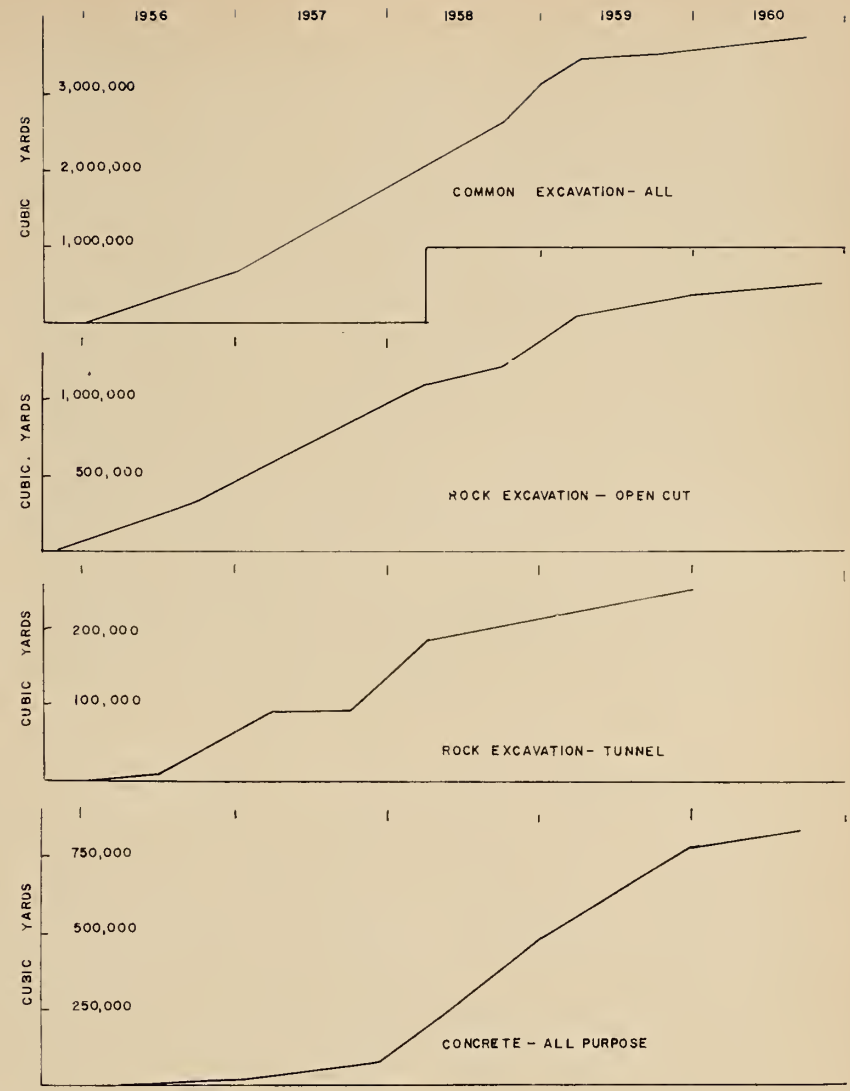


Fig. 4. Progress Schedule

The language barrier continued to be a difficult problem, though many Canadians soon picked up a rough working knowledge of Pashto, the local language. Although the official language of Pakistan is English, which is taught mostly at high school level or beyond, the common language is Urdu, to which Pashto is somewhat similar.

The great majority of Pakistanis are Muslims, one of whose customs is strict adherence to the rules of Ramazan. During this period, which lasts for a month, neither food nor water may be taken between sunrise and sunset, and as a result labour output deteriorated considerably.

Wages paid to Pakistani workmen were based on an 8 hr. day, and varied from about a rupee and a half per day for straight labour to between 6 and 8 rupees for the higher paid daily workers with a few being paid as much as 12 rupees. Transferred directly to dollars, this would mean between 30c and $2.40 per day. Although this looks ridiculously low compared to our standards, it must be remembered that the needs of the Pakistani tribesman are extremely modest, and the cost of the food they eat and the clothes they wear is very low. Anything beyond food and clothing is not a necessity, and few of them have more than bare necessities.

The common diet amongst the tribesmen consists largely of a very coarse bread, and vegetables and fruit when obtainable. They eat little meat, which is relatively expensive. The result is that though they are wiry, strong, and accustomed to a hard life, they have not the physical stamina to do a hard day's work. To improve this situation, the Pakistani authorities instituted a system whereby all workers received a substantial meal on the job, for which they paid 4 annas or about 5 cents. This, combined with their ability to purchase a little better food, gradually improved their physical condition, bringing about an improvement in their output. A bonus system was established in the tunnel work, which greatly improved production.

As mentioned above, most of the workmen were tribesmen, drawn from the immediate vicinity. These men took a certain proprietary interest in the project, to such an extent that it was not easy to bring men from other parts of the country. As no work of this kind had been performed in the vicinity, the skills needed were not available, and most of the crew were trained on the job. Engineers and office workers were brought in without any trouble, provided they could be found and were willing to remain.

It is interesting to note that the traditional method of working a hand shovel is to have either two or three men operate it. One man digs it in, and the other one or two throw the contents by means of pieces of rope attached just above the blade. This, of course, increases the output of shovels, which are in short supply, but certainly does not increase man-hour output.

The job worked six days per week, and most of the equipment was operated three shifts.

Equipment Planning

Certain requirements had to be considered when planning construction equipment.

a) Standardization should be carried as far as practically possible;

b) Purchases should be kept within Canada first, consistent with economy, and within the Commonwealth secondly, again consistent with economy, inasmuch as Warsak is a Colombo Plan Project;

c) As all equipment is to be later turned over to the Government of Pakistan, every effort had to be made to confine purchase to items that would be of best use in the future;

d) Pakistani railroad clearances are somewhat limited.

The great need for standardization can be readily understood. Apart from the reduction of inventory of spare parts, training of repair and maintenance crews is simpler when equipment is from a limited number of manufacturers.

TABLE No. 3
Summary of Equipment and Material Shipped by General Contractor
(Does not include permanent equipment)

	Tons
Major items of construction equipment	2,800
Tunnel arch support (steel)	2,484
Miscellaneous iron and steel	1,578
Reinforcing steel	2,769
Bailey bridge material	1,070
Steel rail	308
Steel sheet piling	464
Steel forms, including tunnel forms	985
Drill steel	177
Lumber and plywood	11,600
Explosives	809
Commissary	653
Personal effects	225
All other items	4,600
TOTAL	30,522

(Total is to January 31, 1960, and balance will be small)

The greater the percentage of Canadian Colombo Plan funds expended in Canada, the less is the drain on the Canadian economy, hence the special requirement to buy in Canada first.

The terms of the inter-governmental agreement provided that all construction equipment be turned over to the Government of Pakistan at the completion of the project. The advantages of such an arrangement to Pakistan are obvious in that the equipment is already on site and assembled, and a number of Pakistanis have been trained in its operation, maintenance, and repair. With this in mind every endeavour was made to restrict equipment to that which would be of future use on any similar project.

It will be seen later that it was not possible to avoid sending a few special items such as cableways, but in general extra large shovels trucks, etc. were not chosen. It is worthy of note that an extension to the original terms of the contract provided for the overhauling of all equipment to put it in good running order before its transfer.

The railroad from Karachi to Jamrud Fort passes over a number of bridges and through tunnels which imposed certain limitations but these were not sufficiently restrictive to cause much trouble.

Repair facilities established at Warsak were considerably more extensive than would be required on a similar job in Canada. (See Appendix). Breakages were heavy, particularly in the early stages of the work, and although a heavy inventory of repair parts was maintained, improvisation was necessary on many occasions. It was not possible to always have available the necessary parts to repair unexpected breakages, nevertheless the equipment was kept operating one way or another. Temporary cannibalization had to be carried out occasionally to avoid too many units of the same type being out of service at the same time. As noted above, it took 3 to 4 months from requisition of parts to delivery at site.

Fig. 5. Excavation for Diversion Tunnel outlet portal

The project is readily divided into 3 main items:

1) Tunnelling through rock;
2) Earth and rock excavation;
3) Concrete placing.

Basic planning for 1) and 2) called for 2 cu. yd. shovels and 15 ton and 22 ton trucks plus standard mine equipment for the smaller diameter tunnel. Later study of the large quantities to be handled in the coffer-dammed area, where operations could only be carried out after unwatering and during the period of low flow, and the probability that operating efficiency would not be above 2/3 of that which would be expected in Canada, indicated the necessity of securing two 4 cu. yd. shovel-draglines in addition to the smaller units.

Placement of concrete in the main dam required considerable study. Conventional methods such as the use of derricks or the construction of a temporary trestle were ruled out by the requirement of placing concrete on the higher levels while the coffer-dams were overtopped, and by the steep banks of the gorge. (See Fig. 2.) The writer suggests that the site almost demanded cableways, and experience has proven that such was the case. Two 11 ton cableways were ordered, to operate on a span of 1,043 ft., with travelling head and tail towers, The sides of the gorge were benched and track laid to cover the entire area of the dam and most of the stilling basin.

A central mixing plant, containing three 2 cu. yd. mixers, supplied most of the concrete required, with an auxiliary plant containing one 2 cu. yd. mixer for additional capacity when needed. Four 6½ cu. yd. transit mixers were used to transport concrete to the power house and other locations not covered by the cableways.

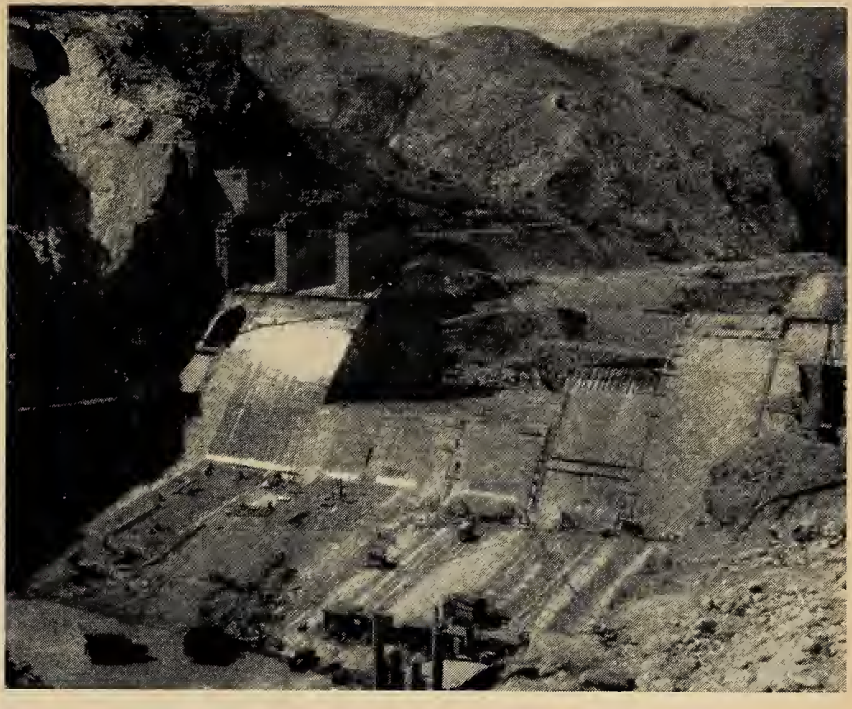


Fig. 6. Main Dam partially completed

Schedule

Preliminary planning called for completion of the project in 1959, which meant that the diversion tunnel, 1700 ft. long with a finished diameter of 35 ft., had to be driven and lined with concrete by September 1956, or about 9 months after the preliminary set-up. Various factors caused revision of this schedule, the chief among them being that insufficient power would be available for the heavy compressor load until midsummer 1956. A more orderly schedule was then set up which allowed time to instal proper repair facilities, organize transportation, build access roads, and establish proper relations with the local Pakistan authorities who were anxious to take as large a part in the work as possible and upon whom depended the supply of men and local materials—their cooperation was essential for the success of the project.

Fig. 4 shows the actual schedule attained, and it will be readily seen that the rate of concrete placement in the dam during the Winter of '58-'59 could only have been achieved on a thoroughly organized job, and is a measure of the success resulting from careful planning, and patient negotiation between the various authorities who found common ground in working for a common aim, resulting in mutual respect and friendship.

The schedule was obviously effected by the capacity of the diversion tunnel, which only permitted working in the river bed when the flow was less than 30,000 c.f.s., or about seven months of the year (Ings[1]). As the Kabul River during flood period carries a great amount of silt, it was imperative that the deep excavation in the centre of the river be filled with concrete to an elevation which would avoid having to excavate large quantities a second time. The concentration of work in the river bottom during the September to April period was therefore very heavy.

Another governing factor in the schedule was the limiting safe velocity in the diversion tunnel, as the concrete lining would have been endangered if the gap in the dam was insufficient to pass the 1959 flood without raising the water above Elevation 1170. This meant that a gap of 150 ft. in the rollway section and three piers had to be left incomplete until the Autumn of 1959.

The remainder of the work, that is the power house, the power and penstock tunnels, and the irrigation tunnel, though of considerable magnitude, was fitted in to the work in the river as required by the overall schedule.

Construction Features

Throughout this paper, an effort is made to describe features which are not ordinarily encountered on work of this nature in Canada, and only such portions of the actual construction work will be covered that are considered unusual.

Access—Reference to Fig. 1. and 2. will show the very limited working area in the immediate vicinity of the principal operations, and the difficulties of access Nearly all the temporary construction buildings had to be located 2½ miles from the site of the work. Access roads to the various working points required far-sighted planning and considerable heavy work to carry them out. As an example, the invert of the diversion tunnel was at Elevation 1092, the excavation for the dam went as low as 1022.5, the central mixing plant was located on a moderately flat area at Elevation 1265, the top of the bulkhead was at Elevation 1290, and the North

Cableway bench was at Elevation 1362. (See Fig. 1 and 2.) These various points were all within a radius of 500 ft., and access to each point had to be worked out. A bridge capable of carrying heavy equipment had to be built across the river immediately below the site, as the nearest crossing was 3½ miles downstream, and was only capable of carrying 24 tons. This bridge, 370 ft. long, consisted of piers of steel sheet pile filled with concrete, and Bailey bridge spans of 120 ft., triple double, good for 70 tons.

The side of the gorge at the location of the dam on the South side was so steep that it was not feasible to maintain access to the upstream area without leaving a hole or tunnel when concreting the South end of the dam. This tunnel was left open as long as possible before being filled with concrete and pressure grouted, after which it was necessary to use the upstream cofferdam for access until the bridge across the dam was completed.

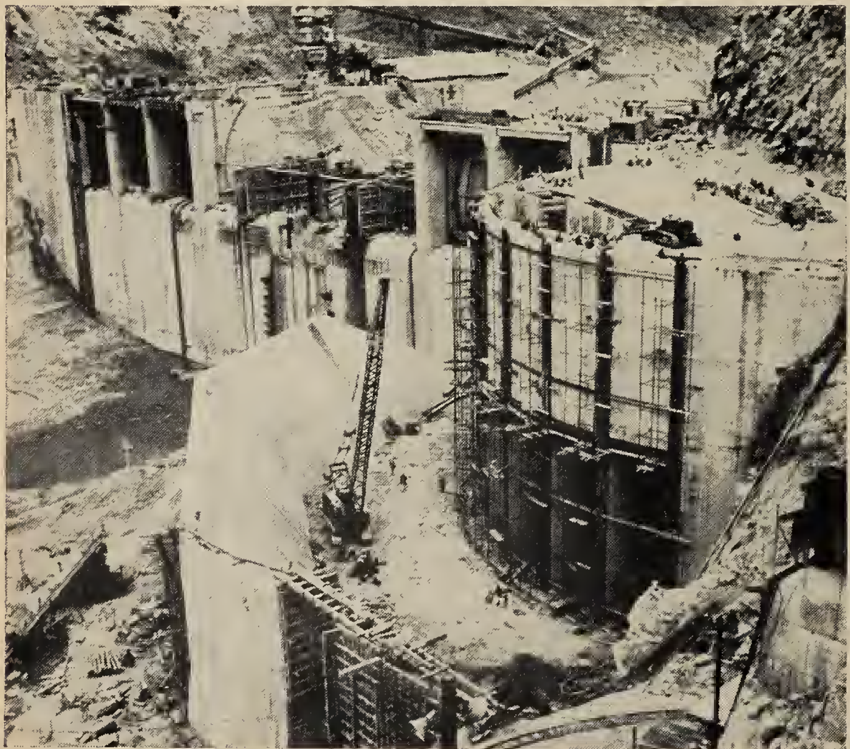
Diversion Tunnel — Driving of the diversion tunnel was carried out from the outlet end by conventional heading and bench method. A movable drilling jumbo on D7 Caterpillar tracks with 20 hydraulic booms was built in Canada for the heading face, excavation was by a 2 cu. yd. shovel with special short boom and dipper stick, disposal was by 15 ton trucks. The entire tunnel had to have steel arch supports and lagging. Concreting of the arch was by pumpcrete into a movable tunnel form 50 ft. in length.

Cofferdams — The upstream and the downstream cofferdam each consisted of two pervious fills with impervious material between them. Thus, there were four fills stretching across the river to close off the flow, which at closure created a total head of approximately 6 ft. Previously, rock from power house excavation had been selected and stock-piled nearby, creating a ready reserve of rock large enough to withstand the velocity of the water. Closure was thus achieved without difficulty. Impervious material had to be trucked some distance from the nearby plain, some of which was likewise stock-piled ahead of time.

In order to ensure that the hydraulic gradient through the upstream cofferdam should be sufficiently steep 16 in. diam. tube-wells were previously driven into the silt immediately below the toe of the slope, and a double row of steel sheet piling was driven through the impervious core of the downstream cofferdam into the underlying overburden. In this way leakage was kept to modest proportions. Actually, the tube-wells were not required.

Reference to the schedule, Fig. 4, shows that the cofferdams had to stand overtopping during the flood of 1958 and 1959. Model testing by the consulting engineer (Ings[1]) indicated the paving of the crest and downstream slope of each cofferdam to prevent erosion. This was done with hand placed rip-rap and cast-in-place concrete of low cement content. The result was entirely successful.

Fig. 7. Power Tunnel Intake, and main dam in background



Excavation — The river bed at the damsite consisted of silt, sand, gravel and boulders deposited by the successive floods of the past centuries. The maximum depth encountered was 90 ft. Reference to Fig. 3 indicates the difficulty of excavating this large volume in the short time available was the chief reason for ordering the two 4 cu. yd. shovel-draglines.

As soon as the area had been unwatered, the large machines went to work as draglines, and the smaller ones proceeded to ramp down to open up the cut for face shovels. The deep excavation under Piers 6 and 7 had to be done by loading into skip boxes handled by cranes at a higher level. The balance of the excavation for the dam and stilling basin did not present any special problems.

Power house excavation into the side of the gorge was preceded by a considerable amount of scaling by hand. The Pakistanis are good at this type of operation but it required many months of work and a debris trench was dug well above the top of the excavation to retain pieces of rock that might roll down later. Further stabilization was necessary in the form of concrete revetment following a rock slide which took place in the first year of operation. The highest point where excavation took place was at Elevation 1,450, and excavation for the floor of the draft tubes was at Elevation 1,080. Here again access roads were a big problem.

Coyote blasting was used with considerable success in the early stages in order to get some of the rock from the higher levels down to where it could be handled by shovels. Of the total amount of power house rock excavation of 523,000 cu. yd. approximately 300,000 cu. yd. were handled by coyote methods.

Power Tunnel & Penstock Excavation — Access to this work had to be through the penstocks, and power house excavation was benched in such a way that access was maintained to penstock invert for shovel and trucks until completed.

First entry was made through penstock No. 1, and all penstocks were excavated full face. The diversion tunnel drilling jumbo was divided in two, each being suitable for a penstock, and mucking performed by Eimco 105 and International TD14 with overhead loader. The power tunnel was then excavated by heading and bench method, using the two modified jumbos side by side to drill the heading, approximately 28 ft. high; excavation was by a Dominion 500 with short boom. The bench was also face drilled by means of modified jumbo.

There was a 42° inclined section near the inlet, part of which was taken out from the inlet end. A pilot tunnel was then driven in the form of a raise from the bottom to meet the upper level, and successive rounds drilled and blasted from the upper level, sending the rock down to where it could be shovel loaded.

The soundest rock (Ings[1]) on the project was encountered on this work, and only at the penstock portals were supporting ribs required. The sound rock continued in the power tunnel until the inclined section was reached, where ribs were necessary. The intersection of the penstocks with the power tunnel incorporated transition sections which produced spans of 60 ft., but sound rock obviated the requirement of arch support.

Irrigation Tunnel — The irrigation tunnel 17,000 ft. long and excavated to an approximate diameter of 12 ft. (actually a modified horseshoe section) was carried out by means of standard mining equipment. A 24 in. gauge railroad was used and mucking was performed by Eimco 21 overhead loaders loading 2 cu. yd. mine cars hauled by battery operated locomotives.

Drilling jumbos travelling on the track were constructed, each with 5 hydraulic booms. Work was carried forward from both the inlet and outlet ends, meeting approximately at the mid-point. Ventilation was achieved by four 5 h.p. fans at each end, supplying air through steel pipe which started at 18 in. diam. and reduced to 15¾ in. diam. Considerable shattered rock was encountered and it was found necessary to support the arch with steel ribs for one third of the distance.

As mentioned previously, the Pakistanis were anxious to take as large a part as possible in the development and early in 1957, it was agreed that the Warsak Dam Project Organization, which is the government agency set up to take part in the project, should do the excavation of this tunnel as a subcontractor with the general contractor assisting where necessary and carrying out general supervision. This worked out well and the two headings met December 28th, 1959.

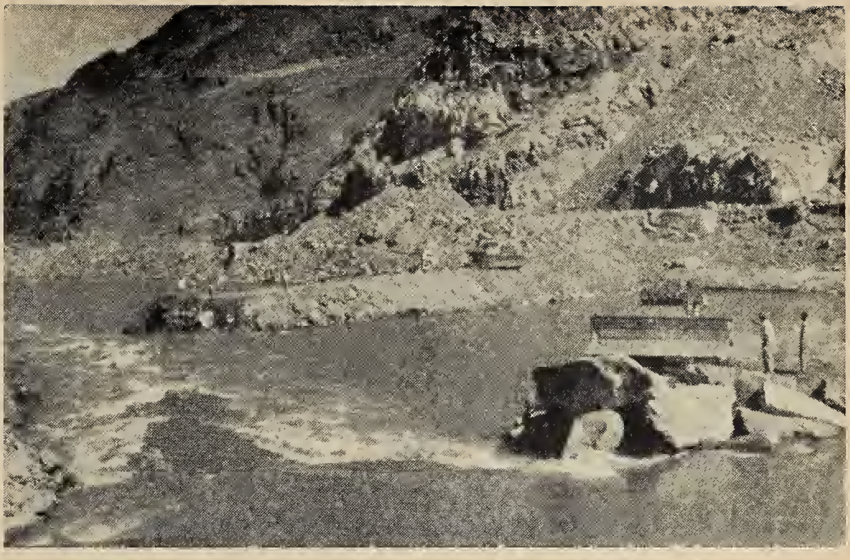


Fig. 8. Placing Selected rock at upstream cofferdam

Concrete for the minimum 15 in. thick lining is being placed by pumpcrete in a 50 ft. tunnel form in each heading, and is expected to be completed in the spring of 1961.

Concrete Placement — The governing factor in the concreting schedule was the necessity of placing sufficient concrete in the dam during the low water period of 1958-59 to achieve a height which would permit concreting to continue on either side of the gap left to pass the flood of 1959. At the same time, the floor of the stilling basin had to be completed in order to avoid having to remove the large volume of silt which would have been deposited in any unfilled excavation.

The above indicated a concrete placement capacity of about 48,000 cu. yd./month in the dam and stilling basin, or roughly the equivalent of the capacity of the main mixing plant, (see Appendix) hence inquiries for cableways were based on this capacity.

A number of manufacturers were contacted, and purchase made of two identical 11-ton Travelift Cableways from British Ropeway Engineering Co. The two units operated on the same tracks, 380 ft. long, laid on benches excavated in the sides of the gorge.

General specifications were:

- 1,043 ft. span
- 22,400 lb. lifting capacity
- 1,200 ft./min. traversing speed
- 200 ft./min. hoisting speed
- 400 ft./min. lowering speed

Concrete was handled in compressed air operated 4 cu. yd. bottom dump buckets, which were loaded at the main mixing plant and brought under the cableway hooks on flat cars travelling on a 36 in. gauge transfer track, hauled by 3½ ton locomotives. Maximum production of the main mixing plant was 49,239 cu. yd. in January 1959, and the maximum placed in the dam and stilling basin using the main and auxiliary mixing plants was 67,224 cu. yd. in the same month. Maximum overall concrete placement rate was 80,172 cu. yd. achieved in February 1959, the mixing plants being supplemented by the transit mixers.

The power house concrete was mostly handled by cranes, and as soon as the substructure had progressed far enough trestle bents were constructed to support Bailey bridge spans capable of carrying the 2 cu. yd. shovels rigged as cranes. Scheduling of this work was not particularly difficult.

Conclusion

The virtual completion of the Warsak project in the Spring of 1960 has brought a considerable measure of satisfaction to all those participating. A little over 4 years ago it was not much more than an ideal, and a number of people with a keen interest in the ideal entertained serious doubt that completion would be realized in so relatively short a time. The organization set up by the inter-governmental agreement called for a degree of understanding and co-operation between the Pakistani and Canadian authorities which, though obviously desirable, appeared to many of us at the outset to be almost impossible of

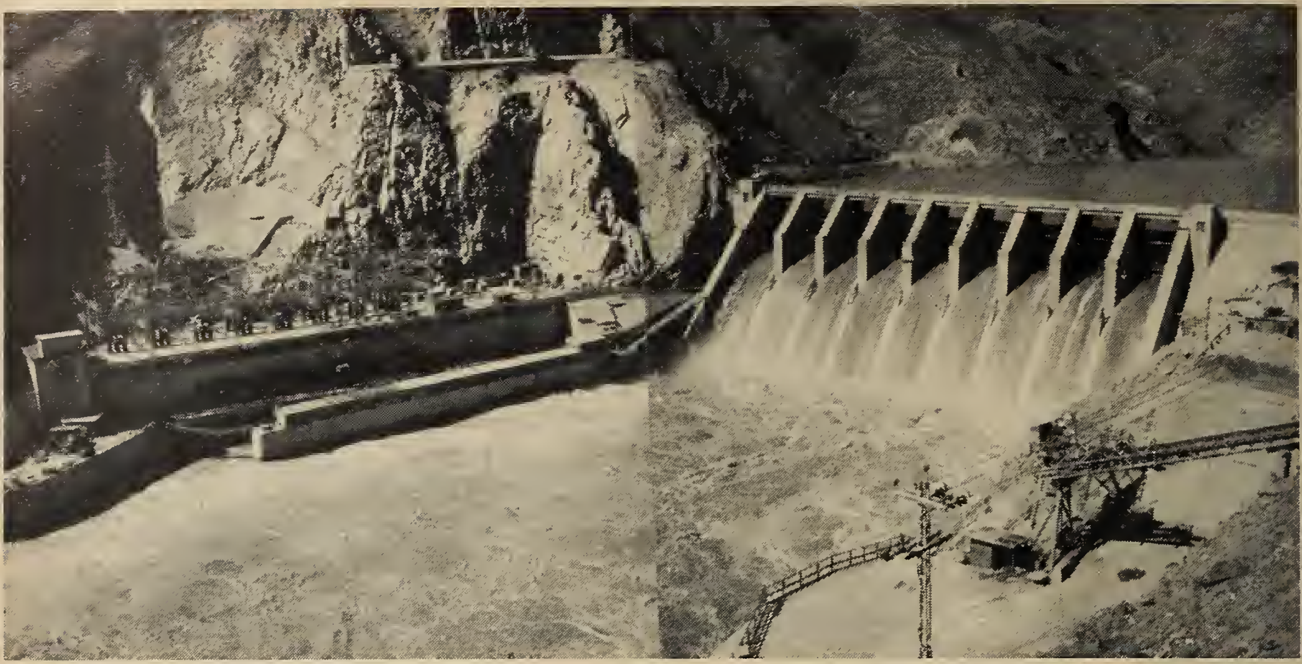


Fig. 9. Main dam and Power House, looking upstream from North bank

attainment. That it was attained in full measure reflects great credit on the people at the site who were determined that Warsak would be remembered as a proof that men of goodwill can work together towards a common ideal even though they started off with little knowledge and understanding of each other.

It would be impractical to attempt to mention all those whose efforts were responsible for the success of the project, and the ensuing list covers only the principals.

In Pakistan: E. L. Miller, Project Manager, H. G. Acres & Co. Ltd.; C. J. Robbins, Manager of Construction, Augus Robertson Limited, to whom I am indebted for assistance in assembling data for this paper; Mohammed Azam Khan, Chief Engineer of Warsak Dam Project Organization; A. R. Qureshi, successor to Azam Khan, following the former's promotion to other duties in 1959; Shah Nawaz, Superintending Engineer, Warsak Dam Project Organization; The Canadian High Commissioner in Karachi and his staff who rendered continuing and valuable assistance.

In Canada: Nik Cavell, Director, Colombo Plan Administration; Orville E. Ault, successor to Nik Cavell, following the former's appointment as High Commissioner to Ceylon; Sheldon Ross, Project Engineer, Foreign Projects Division, Defence Construction (1951) Limited; C. J. K. Smith, Projects Officer, Canadian Commercial Corporation; J. H. Ings, Vice-President, H. G. Acres & Company Limited. (Mr. Ings is writing a companion paper, covering the Engineering aspects of exploration and design of the project.)

Reference

1. J. H. Ings, The Warsak Hydro-Electric Project.

Appendix

List of Construction Equipment, Major Items Only.

1 380—¾ cu. yd. combination shovel
6 500—2 cu. yd. combination shovels
2 1601—4 cu. yd. shovel-draglines
8 TD24 tractors
8 TD14 tractors
8 Wheel tractors
2 105 tractor loaders
1 Grader, Model 550
12 15 ton dump trucks
15 22 ton dump trucks
17 Auto-car 14 ton dump trucks
43 Pick-up trucks, ½ to 3½ ton
1 7 ton fuel oil tank truck
20 Cars and station-wagons
1 75 ton low bed trailer and autocar hauling unit
1 50 ton float
1 TM20—20 ton truck crane
1 TM25—25 ton truck crane
1 Central Mixing Plant, comprising 3—2 cu. yd. mixers, complete with hoppers, etc.
1 Auxiliary mixing plant complete, with 1—2 cu. yd. mixer
5 6½ cu. yd. transit mixers
2 200 single pumpcrete
1 200 double pumpcrete
Bulk cement unloading and handling equipment
3 Bulk cement hauling units
2 11 ton Cableways, designed for 1043 ft. span.
Aggregate processing equipment including 10 in. x 24 in. Jaw Crusher, 24 in. x 16 in. Roll Crusher, Vibrating Screens, Washer Classifier-Dehydrator, Feeders and Conveyors.
5 Compressors, 1,000 c.f.m. electrically driven
4 Compressors, 375 c.f.m. electrically driven, and diesel engine auxiliary drives.
5 Compressors, 210 to 315 c.f.m. diesel driven
42 DA35 Drifters, with power feed
20 FM2 Wagon Drills
48 J40 Jackhammers

Machine Shop, repair and maintenance facilities.

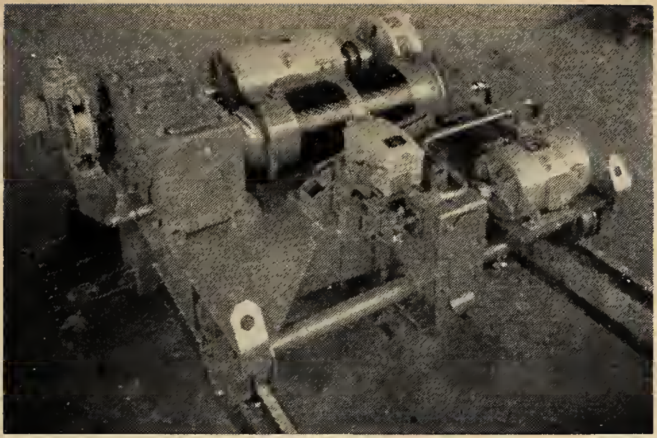
1 Lathe, 8½ x 17 in. swing 8 ft. bed, 4 ft. -6 in. centres
1 Lathe, 7½ x 15 in. swing, 4 ft. centres
1 Screw cutting gap lathe, 28 in. x 48 in. x 20 ft.
1 High speed shaping machine, 20 in.
2 Heavy duty drilling machines
1 Universal milling machine, table 52 x 12 in.
1 Universal iron worker, capacity ⅞ x ⅞ in.
4 Bolt and pipe threading machine, ¼ to 2 in. pipe size
1 100 ton shop press
1 200 ton shop press
1 Pneumatic power hammer, 2,550 ft. lb. blow energy
1 Precision line boring machine, capacity up to 4¾ in. bearings
1 10 ton travelling gantry crane
1 Hydraulic Universal cylindrical grinding machine, 13 in. swing over table, 41 in. between centres.
1 Automatic bar bender, for use up to 1½ in. diam. steel.
Diesel injection special repair and overhaul equipment
9 Welding machines diesel driven
15 Welding machines electric driven

Irrigation Tunnel Equipment

5 4 ton electric locomotives
40 2 cu. yd. side dump cars
12 4 ton flat cars
2 Dynamite cars
2 21 Rocker shovels
Ventilating fans, pipe, etc.

Miscellaneous Equipment

1 25 ton stiffleg derrick, 70 ft. boom
Carpenter shop equipment, complete with necessary wood-working tools.
87 Pumps, various, up to 10 in.
1 9 B3 pile hammer
1 No. 80 pile extractor



DESIGN OF INDUSTRIAL GEARS

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

An investigation into the methods of crane design has been carried out and the results are embodied in this paper with the thought that crane users and possibly others, may find the subject of interest. The reasons for this investigation were manifold. It has been felt for some time that existing general gear design methods are difficult to adapt to crane requirements. For example, the American Gear Manufacturers' Association (A.G.M.A.) specifications, "Strength of Spur Gear Teeth" and "Strength of Helical and Herringbone teeth" apply only to precision cut gearing. The corresponding specifications for "Durability" do not state what surface finish is used as the basis for calculation. Moreover, the use of A.G.M.A. strength formulae imposes an uneconomical amount of work on a design office as these formulae require a layout of tooth profiles to be made for each set of gears to be designed. The Lewis formula, used for many years by crane designers, gives no indication of durability and requires experience to apply it successfully. British Standard Specification 436 is more complete and has wider application to crane gears than A.G.M.A. but has less acceptance in North America and suffers from the defect that its helical gear system is based on constant pitch diameter rather than on the standard normal pitch system used by Dominion Bridge. The B.B.S. addendum modification system is also different to D.B. standard.

NONE of the mentioned design methods relates the face width of gears to the pitch, this being left to the experience of the designer. This has long been felt by the writer to be a serious weakness in existing practice and was one of the main factors prompting the investigation.

In addition to the inadequacies of existing design methods, the increasing use of heat-treated alloys and the ever-expanding range of materials available, made it imperative to establish a logical basis of design that would take into account and make the best use of the enhanced physical properties of these materials.

The investigation, therefore, was planned to establish a method of design which would enable, firstly, the face width of a pinion and gear transmitting a given tooth load at a given speed, to be determined with respect to the materials used, tooth modification and tooth deflection. This calculation requires the setting up of allowable surface stresses and tooth surface form factors, as the face width is a measure of durability. Secondly, the face width calculated from the foregoing is used in a strength formula which gives the minimum pitch necessary to carry the tooth load with adequate regard to the materials used, their fatigue strength, yield point and the properties of the tooth section.

Having established the face width and pitch as above, we have arrived at the optimum relation between these quantities and nothing is gained by varying this relation, with the single possible exception that for helical gears overlap may require a wider face than that calculated on durability and deflection.

Scope

The gears used on overhead travelling cranes fall within fairly narrow limits as regards size, pitch and nature of loading. Speeds are relatively slow and therefore there is no necessity to employ precision cut gearing. Electric motors used as prime movers do not usually run at speeds in excess of 1800 r.p.m. and braking systems are designed to limit lowering speeds to values approximating full load hoisting speeds or less.

All crane gears are subjected to intermittent loading which may vary from a maximum to a value depending on the part of the crane under consideration. For example, the hoisting gear loads can vary from maximum to almost zero, but these gears are subject to heavy shock loads without reversal of direction of loading. The bridge travelling gears, on the other hand, have a much more con stant load pattern with less shock, bu are subject to direction reversals especially where reverse plugging control is used. However, as these factors taken together in each case result in approximately similar dynamic effects it was decided that the gears for all motions of electric overhead travelling cranes would be designed to the same stresses in order to simplify the calculations and obviate the possibility of errors in application.

To conform to the modern concept of classification of cranes by duty, it was also necessary to assess the durability and strength of the gears when used in varying classifications and a series of duty factors for these aspects has been evolved. These correspond to the "daily hours running time" in B.S.S. 436.

Finally, it was felt necessary to conduct a running test to check the validity of the design method and this was carried out.

General: Involute Gears, in order to operate successfully, must satisfy the following conditions:

(a) The teeth acting as small cantilevers must have sufficient strength to resist the applied load (tooth load) in such a manner that the bending stress and deflection is within predetermined limits. This condition fixes the product of tooth size and face. Thus strength requirements can be satisfied with a coarse tooth system and a narrow face or a fine tooth system and a wide face, or any other set of combinations.

However, deflection requirements are not satisfied by a fixed product of tooth size and face width as deflection is independent of pitch. This may be illustrated as follows:

For any cantilever:

$$\delta \sim \frac{wl^3}{I} \sim \frac{wl^3}{bd^3}$$

In a gear tooth:

- l represents tooth depth
- d " " width
- b " " face
- w " " load

It is obvious that l/d is constant for all pitches and thus l^3/d^3 is constant.

Therefore, $\delta \sim w/b$ which is tooth load per unit face. This demonstrates that it is possible to design a gear of Face/D.P. ratio that satisfies strength requirements but not deflection requirements.

(b) The teeth must be capable of withstanding the applied load without exceeding a predetermined surface stress. Excessive surface stress will manifest itself as:

(i) Pitting—caused by surface fatigue which forms a surface crack. Under the action of hydrostatic pressure of the lubricant in the crack, sections of the surface flake away leaving a small pit.

(ii) Scoring—caused by excessive local heat resulting in the tendency of the two mating surfaces to weld together and tear, or score.

(iii) Wear—the result of mild abrasive action. Wear is accelerated if surface stress is high enough to break down the oil film leaving metal to metal contact.

(iv) Ridging—plastic flow of the surface material takes place causing the metal to be pushed up into a ridge across the face of the teeth.

For a given tooth load and material the surface stress is basically proportioned to:

(a) Face width;

(b) Relative radius of curvature of the mating teeth.

It is independent of tooth size.

Since relative radius of curvature is proportional to the respective base circles and the pressure angle, it is proportional to the pinion P.C.D. and the gear ratio, if the pressure angle remains constant.

Addendum modification if employed, will also influence the relative radius of curvature.

Thus it can be said that surface stress is proportional to:

(i) Face width
(ii) Pinion diameter
(iii) Ratio
(iv) Tooth modification
(v) Material

Surface Stress Formula

$$F = \frac{W \cdot Cw}{XcScQ}$$

where F — Face
W — Tooth Load (lb.)
Q — Surface Form Factor
Xc — Speed Factor
Sc — Surface Stress Factor
Cw — Classification Factor

Table I. Equivalent Tooth Load Fd for Static Tooth Load Ft = 1000 lb. k = 1,600 (Precision Gears)

Pitch Line Velocity in Feet per Min.

Face in	*1*		*10*		*100*		*500*		*1000*		*1500*	
inches	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*
1 inch	1003	0.996	1026	0.975	1232	0.812	1856	0.54	2290	0.438	2250	0.392
4 inch	1004	0.995	1043	0.960	1406	0.715	2670	0.375	3720	0.269	4450	0.225
10 inch	1006	0.994	1065	0.940	1627	0.616	3730	0.268	5580	0.179	7200	0.139

The method of deriving the various factors will be briefly described:

Surface Form Factor: The action of two gear teeth in contact is similar to two cylinders rolling together. However, in addition to the rolling, some relative sliding takes place, the amount of sliding increasing as the point of contact moves away from the pitch point (the point of contact at the P.C.D.).

Hertz has suggested an expression giving the maximum surface stress between two cylinders in contact:

$$S = 0.418\sqrt{\frac{Fu \cdot E}{Rr}}$$

where S = max. surface stress
Fu = load per inch of line contact
E = Youngs modulus
Rr = Relative radius of curvature.

Merritt has suggested that an alternative criterion of stress conditions is provided by the expression:

"Surface Stress"

$$= \frac{\text{load/inch of line contact}}{\text{Relative radius of curvature}}$$

$$\text{or} \quad Sc = \frac{Fu}{Rr} \qquad (2)$$

It must be recognized that Sc is not an actual stress but is a mathematical term indicating stress conditions. Substituting for Fu/Rr in equation (1) and assuming $E = 30 \times 10^6$

$$S = 0.418\sqrt{Sc \times 30 \times 10^6} \qquad (3)$$
$$= 2290\sqrt{Sc}$$

As a convenience for calculation an equation may be introduced equating tangential tooth load to Sc for unit D.P. and unit face. Therefore:

$$W = Sx \times \text{Constant} \qquad (4)$$

where W = tangential tooth load
Sc = a predetermined allowable figure.

The constant is sometimes referred to as a "zone factor"—(Z)

$$Z = \frac{W}{Sc} = \frac{Fu \cos\alpha}{Sc} = \frac{Fu \cos\alpha}{Fu/Rr}$$
$$= Rr \cos\alpha$$

where α = pressure angle.

Therefore, $Z = Rr \cos\alpha$ (5)

(See Fig. 1).

Relative Radius of Curvature

$$Rr = \frac{R_1R_2}{R_1 + R_2} \qquad (6)$$

$$R = \frac{d}{2}\sin\alpha + K \operatorname{cosec}\alpha\frac{P_0}{2} \qquad (7)$$

$$R = \frac{D}{2}\sin\alpha - K \operatorname{cosec}\alpha\frac{P_0}{2} \qquad (8)$$

$$P_0 = p\cos\alpha$$

For 1 D.P.

$P_0 = \pi\cos\alpha$
D = T (Number of teeth in gear)
d = t (Number of teeth in pinion)
K = addendum modification (in.)

Substituting in equations (6) and (7)

$$R = \frac{t}{2}\sin\alpha + K \operatorname{cosec}\alpha - \frac{\pi}{2}\cos\alpha \qquad (9)$$

$$R = \frac{T}{2}\sin\alpha - K \operatorname{cosec}\alpha + \frac{\pi}{2}\cos\alpha \qquad (10)$$

An examination of equations (5), (6), (9) and (10) will reveal the fact that Z is dependent only upon teeth in pinion and gear ratio, if D.P. and pressure angle remain constant. A series of Z curves can be produced by plotting number of teeth in pinion against gear ratio. It will be found that for any given pinion diameter and gear ratio, Z is fairly constant regardless of D.P. of teeth. For uncorrected teeth Z would be independent of D.P. and depend upon pinion teeth and ratio only. However, if for any given pinion diameter and ratio the value of Z is calculated for all D.P.'s likely to be used, an average value of Z/P can be determined which will have sufficient accuracy for all practical purposes.

In the surface stress formula

$$Q = (Z/P)$$

is a measure of the ability of the pinion to carry a given tooth load at a given surface stress. Tangential load $W = Sc.Q$ for 1 in. face and for any number of size of teeth under static conditions.

Table II. Equivalent Tooth Load Fd for Static Tooth Load Ft = 1000 lb. k = 5000 (Industrial Gears)

Pitch Line Velocity in Feet per Min.

Face in	*1*		*10*		*100*		*500*		*1000*		*1500*	
inches	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*	*Fd*	*Xc*
1 inch	1004	0.995	1039	0.964	1363	0.735	2460	0.407	3350	0.300	3950	0.254
4 inch	1007	0.994	1072	0.934	1700	0.590	4090	0.245	6380	0.157	8160	0.123
10 inch	1011	0.990	1112	0.900	2110	0.474	6070	0.165	10250	0.098	13680	0.073

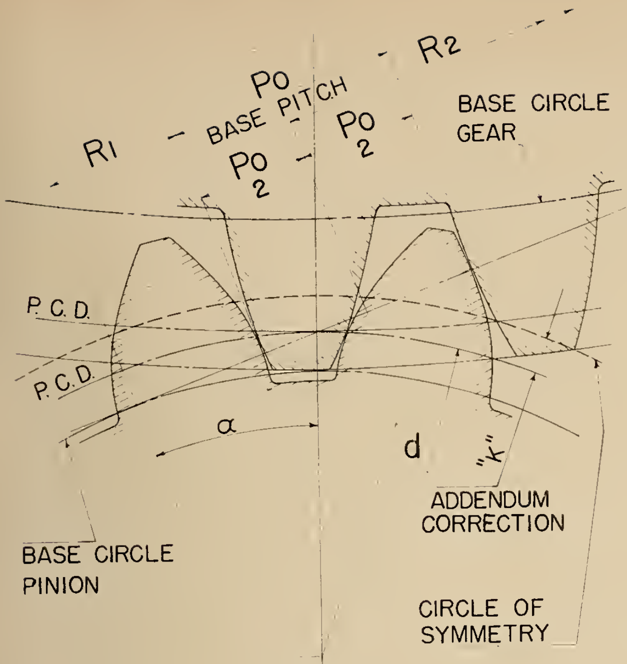


Fig. 1.

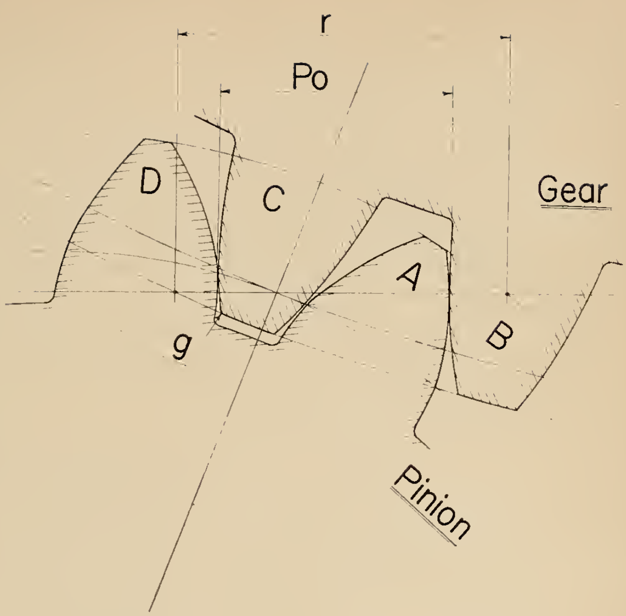


Fig. 2.

Xc-Speed Factor: Various authorities have proposed expressions relating dynamic stresses to the pitch line velocity of the gears. However, most of these seem to be based on the work of Earle Buckingham who has suggested that the maximum instantaneous load on a tooth (dynamic load) is:

$$Fd = Ft + Fi = Ft + \frac{0.05V(kf + Ft)}{0.05V + (kf + Ft)}$$

where

- Fd = total equivalent load applied at the pitch line
- Ft = tangential load required for power transmission
- Fi = the increment load
- k = a factor depending on machining errors
- f = face width
- v = pitch line velocity

the above equation indicates that the dynamic load is proportional to:

1. Pitch line velocity
2. Tooth errors
3. Face width.

To illustrate the effect of these three factors the value of Fd has been computed for various pitch line velocities and face widths. Two values of "k" have been chosen; one to represent Precision Gears having tooth errors of 0.001 in. for 1 D.P. and the other to represent Industrial Gears having tooth errors of 0.003 in. for 1 D.P.

From an examination of Table 1 and Table 2, the effect of tooth error is apparent. The effect of speed can also be readily appreciated. However, the effect of face width merits further attention. From Table 2, it will be observed that a nominal tooth load of 1000 lb. at a pitch line velocity of 1000 f.p.m. is increased to 3350 lb. on a 1 in. face and 10,250 lb. on a 10 in. face. Thus the dynamic effect for a 10 in. face is over 3 times that for a 1 in. face. It is difficult to understand the extreme effect of face width if tooth errors are considered constant. However, it must be noted that face width is indicative of gear inertia and for a given tooth error and speed the dynamic effect would be roughly proportional to the inertia of the gear. Tooth error given is an average value, so the maximum error could conceivably be proportional to face width.

Although the effect of face width on dynamic stresses may appear rather excessive, the indications are that it is an effect that cannot be ignored. The expression

$$Xc = 1 - \frac{\sqrt{V}}{50}$$

although empirical gives results comparable with the Buckingham values in the lower speed range, but not in the higher speed range where Buckingham values indicate more severe dynamic effects, especially in the wider faces. It is felt that this departure is justified because:

1. The effect of dynamic forces usually shows up as a fatigue failure—either surface fatigue or flexural fatigue. In the case of the softer materials tooth wear should reduce errors with a resultant reduction in dynamic effect long before the cycles necessary to cause a fatigue failure are reached. In the case of very hard gears they are either ground precision gears with small tooth errors or when commercially cut are designed with a proportionately lower stress, e.g., Carburized gears, if taken to the limit would be given an allowable stress factor (Sc) of 8000 whereas the recommended value would probably not exceed 5000.

2. The dynamic stresses on gears having tip relief must have an upper limit, as severe stresses with accompanying deflection would cause an increase in the contact ratio. In other words, extreme stresses on one pair of teeth will cause such a deflection that the next tooth will come into action earlier than otherwise. This is particularly true of high speed gears of high tensile material. (Note: Item 2 is an opinion only as no calculations have been made to prove the point.) Table 3 is a comparison of speed factors prepared by various authorities.

However, a 4 in. ϕ is assumed so that pitch line velocity is approximately equal to r.p.m. These B.S.S. values have been taken from the "combined speed and running time" graph using the "12 hour per day" curve at which running time is 1.0 and has no effect. It should be noted here that the B.S.S. factors appear illogical, as the basis of relating speed factors to r.p.m. gives a different value for pinion and gear, surely incorrect when it is considered that one tooth constitutes the action while the other, the reaction. The differences are in direct proportion to the ratio of the pair.

It would appear from an examination of Table 3 that the Lewis speed factors correspond more closely to the recommendations of Buckingham. However, such a comparison cannot be made as some authorities require an additional face factor and others do not. Table 3 shows values for a 1 in. face. Compare this with Table 4 for a 10 in. face.

The suggested factors are more liberal than those of Buckingham for the reasons given. A comparison of Tables 3 and 4 indicates the undesirability of employing large face gears on crane and similar mechanisms.

Surface Stress Factor—Sc: The surface stress factor is related to the actual surface stress by the expression

$$S = 0.418\sqrt{Sc \cdot E}$$

For steel mating with steel this reduces to

$$S_{max.} = 2290\sqrt{Sc}$$

If S be given the value of the surface endurance limit, Sc can be calculated, e.g., assuming a B.H.N. = 200, the surface endurance limit is approximately 70,000 lb. per in.
Therefore,

$$Sc = \left(\frac{70{,}000}{2290}\right)^2 = 940$$

This is a low value which does not take account of :

1. The work hardening of the softer mating surface by the harder ;

2. The easing of the surface stress concentration by the supporting film of lubricant.

Work Hardening—In the proceedings of the Conference on Lubrication and Wear, 1957, there are records of increases of 50 points of B.H. values due to work hardening. On this assumption, the endnrance limit would increase from 70,000lb. per in. to 90,000lb. per in. and Sc would increase from 940 to 1540, a rise of 64 per cent.

Table III. Speed Factors for Industrial Gears — 1-inch Face

Authority	*Formula*	*Pitch Line Velocity—F.P.M.* 1	10	100	500	1000	1500
Buckingham	See Page 3	0.995	0.964	0.735	0.407	0.300	0.254
Lewis	$600/(600 + V)$	0.999	0.985	0.858	0.545	0.375	0.285
A.G.M.A.	$1 - (\sqrt{V/84})$	0.988	0.962	0.881	0.733	0.624	0.535
B.S.S. 436	See Graph *	1.00	0.625	0.410	0.310	0.260	0.240
Merritt	$(1/V)^{0.2}$	1.00	0.630	0.400	0.288	0.250	0.231
Writer	$1 - (\sqrt{V}/50)$	1.00	0.937	0.800	0.552	0.368	0.225

*Speed factors according to B.S.S. are based on R.P.M., not pitch line velocity.

Lubricant Support — Fundamentally the Hertz formula

$$S_{max\cdot} = 0.418\sqrt{\frac{Fu \cdot E}{Rr}},$$

is the measure of load intensity over a small area of Contact A
where $A = F \times \delta$
F = face width
δ = width of area of contact
if, however, the mating surfaces are separated by a film of oil as is the case with mating gears, it is reasonable to suppose that the width δ will increase with a resultant decrease in specific stress.

The Sc values given in B.S.S. 436 are considerably higher than those calculated on the basis of the surface endurance limit of the material, e.g., a steel of B.H.N. 200 is given an allowable Sc value of 2350 as against 940 calculated by the Hertz formula. However, when the effects of Work Hardening and Lubricant support are considered these would seem to be reasonable figures, especially as they are put forward as a result of experience. They will therefore be adopted.

Classification Factor

Since there is apparently no established limit of endurance for surface stress conditions, it would appear that the life of a pair of gears based on surface stress conditions would be proportional to the total number of tooth contacts. Thus a gear running at, say, 500 r.p.m. would have twice the endurance of a gear running at 1000 r.p.m., other things being equal.

However, experience indicates that this rule is not valid; in fact, quite often the very opposite applies, i.e., a faster running gear will sometimes show less surface deterioration than a slow running gear, other things being equal. Darle W. Dudley in his book *Practical Gear Design* reports as follows—"In one recent test by the author a set of precision spur gears was operated for 20 million cycles at a pitch line speed of 6000 f.p.m. Involute measurements showed wear to be less than 0.0001 in. Then the set was run at 1000 f.p.m. with the same torque. After 5 million cycles at this speed, the set was stopped. Wear was measured at 0.0005 in."

B.S.S. 436 apparently takes into account this phenomenon. The following data has been extracted from the graph "Combined Speed and Running Time Factors for Spur and Helical Gears—Wear"—Page 59.

Fig. 3.

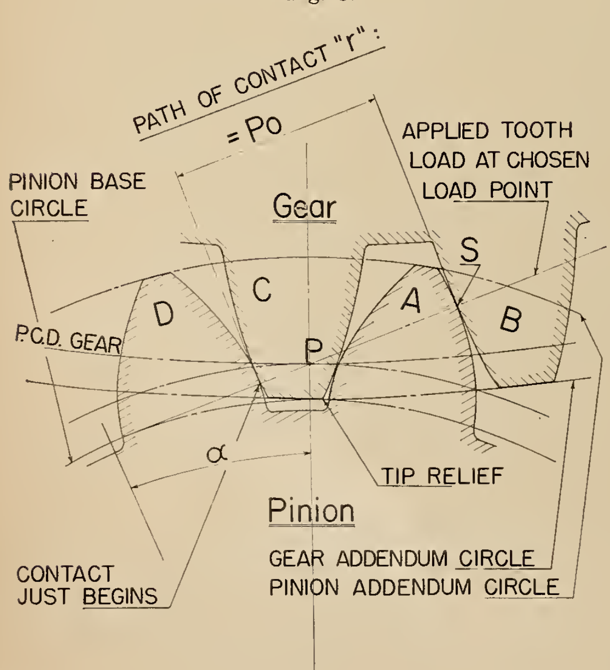
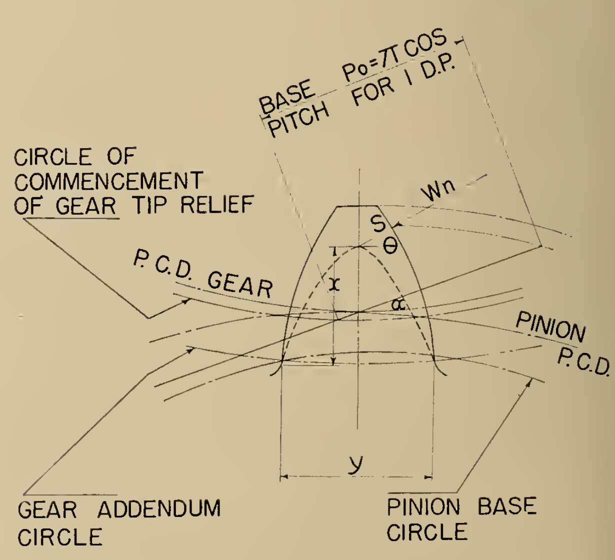


Fig. 4.



	1	*Gear Speed — r.p.m.* 1200	8000
Hours per day	0.5	0.1	0.05
Total cycles*	65,000	15,600,000	52,000,000
Sc given	3.0	1.25	0.875
Speed factor	1.0	0.25	0.14
Actual *Sc*	3.0	5.0	6.25

*The basic life span is 26,000 hours for a gear in continuous use for 12 hours per day. For less hours per day, the life span remains the same but the total number of effective working hours is reduced in proportion, e.g., a gear running for one hour per day would have the life span of the 12 hour per day gear but the effective working hours would be (26,000/12) = 2168 h.

An examination of the above table reveals the fact that a gear making 52 million contacts is permitted an *Sc* value more than twice that of a gear making only 65,000 contacts; apparently due to the higher speed enabling a better lubricant film to be developed.

It must be concluded from these facts that it is extremely difficult if not impossible to predict the life of a gear on the basis of surface fatigue or wear if an adequate lubricant film is maintained and abrasive matter is excluded. The life, although indefinite, will be of considerable duration. High speed turbine gears have been known to run for a year or more and show so little wear that the original machining marks although a few microinches deep were still visible on the tooth surface. During this period many millions of contacts would have taken place. The same absence of wear is sometimes to be noticed on automotive gearing.

Apparently surface deterioration is experienced when the lubricating film breaks down either partially or completely either by excess surface pressure or heat or both. Rough surfaces may also be a cause.

In the absence of more reliable data, it would seem reasonable to base life on the number of starts to which a gear is subjected. During starting, tooth lubrication is poor and metal to metal contact is to be expected, at least, partially. When full speed has been attained, the high speed gears have the benefit of better lubrication, but the low speed gears have the benefit of a smaller number of contacts. It will be assumed that the total effective hours of service will be indicative of the total number of starts so gear life will be based upon the total effective hours of service irrespective of speed. The effect of speed on tooth loading will be allowed for by the application of the speed factor.

A reasonable gear life would seem to be 20 years for wear as deterioration can be observed and replacements made, if necessary. On the basis of 300 working days per year, at 4 hr. per day at maximum load, the total time of maximum load would be 24,000 hr. It is not expected that any general service crane would exceed these hours for any one motion.

Taking the example of a hoisting motion: assuming a hoisting speed of 10 f.p.m. and a lift of 10 ft.:

Time to hoist and lower = 2 min.

Load handled in effective 4 hr. period

$$= \frac{4 \times 60}{2} = 120$$

Over an 8 hr. period, this would constitute a load handled every four minutes.

On the basis of British Standard recommendations for effective full load period, an average bucket crane has an effective four hours per day working period for the closing mechanism.

On this basis, a maximum working period of four hours per day, or 24,000 hr. total working life will be adopted for a Class D crane. Class D will be the basic class and given a classification factor of 1.

A Class A crane will be assumed to have an effective working period of one half hour per day, or 3,000 hr. total life. On the assumption of 5 f.p.m. hoist speed and 20 ft. lift, over an 8 hr. period, a full load could be handled every 32 minutes. This should amply cover all Class A crane applications.

Similar examples could be given for the other crane motions.

Gears will be classified for surface durability as follows:

TABLE V.

Class	Hours Per Day	Total Life—Hours
A	1/2	3,000
B	1	6,000
C	2	12,000
D	4	24,000

The classification factor "*Cw*" is in reality an adjustment of the basic surface stress in order to take advantage of the shorter life required for crane gears of classes lower than D.

Assuming partial metal to metal contact the life of a pair of gears is a function of load and time of running. If the tooth load is excessive, pitting or rapid wear will result in a short time. If it can be established that a pair of gears subjected to a surface stress *Sc* will work successfully for a time *t*, then it can be proved that they will work for a longer time if the stress *Sc* is reduced, or vice versa. Final breakdown may be the result of wear or surface fatigue.

Thus, if t_0 is the life of a pair of gears loaded to a surface stress, S_0, then the life *t* at a surface stress *Sc* is given by the expression

$$t = t_0 \left(\frac{S_0}{Sc}\right)^x$$

where x is a power determined by experiment.

Many authorities give the value of x as 3.

$$S_c = \frac{S_0}{C} \quad \text{and} \quad t_0 = 4$$

where C is the classification factor.

Therefore,

$$\frac{t}{t_0} = \left(\frac{C \cdot S_0}{S_0}\right)^3 = C^3$$

Therefore,

$$C = \sqrt[3]{\frac{t}{t_0}} = \sqrt[3]{\frac{t}{4}}$$

(See Table 6.)

These factors apply to gears encased in a gear box where lubrication is adequate and the ingress of dirt is prevented. *External gears shall be classified one higher than normal to allow for the less favourable conditions.*

It is of interest to compare these classification factors with other authorities.

H. H. Broughton provides an expression for life factors with

$$KW = \sqrt[3]{\frac{27,000}{100 + T}}$$

total life being 26,000 hr.

(See Table 7.)

The B.S.S. 436 expression is

$$Ku = \sqrt[3]{\frac{u}{12}}$$

where u = required hours per day. This assumes a factor of 1.0 for 12 hours per day. On the basis of 4 hours per day for a factor of 1.0 the expression would be modified to

$$Ku = \sqrt[3]{\frac{u}{4}}$$

Table IV. Combined Speed and Face Factor for Industrial Gears — 10-inch Face

Authority	*Formula*	*Pitch Line Velocity — f.p.m.* 1	10	100	500	1000	1500
Buckingham	See Page 3	0.990	0.900	0.474	0.165	0.098	0.073
Lewis	$600/(600 + V)$	0.999	0.985	0.858	0.545	0.375	0.285
A.G.M.A.	$1 - (\sqrt{V/84})$*	0.750	0.730	0.625	0.521	0.337	0.288
B.S.S. 436	See Graph *	1.00	0.625	0.410	0.310	0.260	0.240
Merritt	$(1/V)^{0.2}$	1.00	0.630	0.400	0.288	0.250	0.231
Writer	$1 - (\sqrt{V/50})$	1.00	0.937	0.800	0.552	0.36	0.225

*Included in these values is a face factor based on A.G.M.A. face factor curves.

which would give factors identical to those in Table 6.

The tooth action of a pair of gears is not unlike the action of a roller bearing, the difference being that roller bearings are not subjected to sliding as well as rolling. However, a gear surface fatigue failure usually shows up at or near the pitch line where little sliding takes place. There is also a marked similarity in the type of surface fatigue failure between gear teeth and roller bearings. The S.K.F. Co. gives an equation for the determination of the life of a bearing

$$L = \left(\frac{C}{P}\right)^{3.33}$$

where L = life, C = basic dynamic capacity of the bearing, P = applied load.

It can be readily observed that the formula resembles that given by the writer :

$$t = t_0 \left(\frac{S_0}{S_c}\right)^3$$

t is equivalent to L
t_0 is unity
Sc and S_0 correspond to P and C respectively.

The only difference between the expressions is that the S.K.F. equation provides for a greater number of working hours with a decreasing load and the writer's equation provides for a shorter number of working hours with an increased stress or applied tooth load.

It must be recognized that there is a limit to the lower value of the wear classification factor. As indicated, the classification factor is really an adjustment to the allowable stress to take advantage of the shorter working periods. However, just as an anti-friction bearing has a static capacity above which a bearing may not be loaded because of danger of failure by yielding, so a gear tooth has a limit stress above which the metal of the tooth will yield or the lubricant will "flash" causing welding and scoring of the teeth. This limit is difficult to determine by any means other than destructive tests. The classification factors have been suggested on the assumption that this limit will not be reached, so it is recommended that a pair of Class A gears be designed in accordance with the formula given and tested to determine the validity of the values suggested for the various terms. Having made the determination it can be assumed with reasonable confidence that the other classes of gears will give satisfactory performance ; in all events an early failure will be most unlikely.

Table VI.

Class	*Hours per Day*	*Classification Factor CALCULATED*		*Classification Factor TO BE ADOPTED*
A	0.5	$\sqrt[3]{5/4}$	0.5	0.5
B	1	$\sqrt[3]{1/4}$	0.632	0.6
C	2	$\sqrt[3]{1/2}$	0.795	0.8
D	4	$\sqrt[3]{1/1}$	1.00	1.0

Table VII.

Class	*Hours per Day*	*Total Hours*	*Classification Factor "K" according to Broughton*	1/K
A	0.5	3,250	1,855	.540
B	1	6,500	1,530	.655
C	2	13,000	1.245	.800
D	4	26,000	1.000	1.000

Face Factor

The necessity for a face factor is evident when it is considered that although during assembly a pair of gears may be adjusted for perfect alignment, shaft and other deflections under load will cause alignment error. This error tends to allow only point contact between the teeth at one end of the face so it is necessary that the teeth deflect before full or partial face contact is achieved. Theoretical adjusting factors to allow for this effect can be alarmingly high. However, the calculations for such factors do not take into consideration :

1. Rapid wear at the running-in stage tends to offset the error.
2. Actual tooth yielding or tooth surface yielding may take place in the softer gears.
3. In the calculations of shaft deflection the load is taken at the centre of the gear face but in fact, the deflection of the shaft will cause the centre of pressure to move away from the centre of the face towards the bearing so the shaft deflection is considerably less than calculated.
4. Tooth deflection is a function of the load per unit face and the elasticity of the material, so although hard gears do not receive much relief from wear they have the benefit of the greater deflection which will tend to distribute the load across the tooth face.

Taking the example of a gear box having several pairs of gears, it can be demonstrated that the higher speed gears would require a greater face factor than the lower speed gears. Due to the more favourable speed factor and greater zone factor (zone factor is proportional to pinion size which is usually greater in the low speed trains) the load per inch of face is higher for the low speed reductions so that the deflection has a greater influence on assisting stress distribution across the gear face. Moreover, first motion pinions are often cut into a long slender shaft at one end where angular deflection is considerable. Torsional deflection has also often to be considered. Intermediate shafts have more favourable conditions for although the shaft is stiffened by the pinion and gear the maximum bending stress is calculated for the small section of shaft between gear and pinion. Considering these facts it would seem reasonable to grade the face factors commencing at the first reduction which should have the most unfavourable factor. A.G.M.A. have produced a series of face factors apparently taking these arguments into consideration.

Rather than employ a face factor which is at the best an estimation based on experience, it has been omitted and the speed factor curve given a bias to make some allowance for poor face contact due to shaft deflection.

Spur Gear Strength Formula:

$$\frac{P}{Y} = \frac{Xb \cdot Sb \cdot F}{W \cdot Cs}$$

where
P = Diametral Pitch
Y = Tooth Form Factor
Xb = Speed Factor
Sb = Allowable Bending Stress
F = Required face as determined by surface stress formula
Cs = Classification Factor.

Tooth Form Factor (sometimes referred to as "strength" factor) : The form factor Y is a measure of the strength of the tooth and may be likened to the section modulus "Z" of a shaft or beam. If for a gear of 1 in. face and given profile and chosen load point, the bending stress is computed for a tangential tooth load Wt, then

$$Sb = \frac{Wt}{Y}$$

where Sb = the bending stress
Wt = tangential tooth load
Y = tooth form factor.

For any face and D.P.

$$Sb = \frac{Wt \times P}{f \cdot Y}$$

where f = face width
P = D.P. of tooth

Therefore,

$$Y = \frac{Wt \times P}{f \cdot Sb} \quad \text{or} \quad Sb = \frac{Wt \times P}{f \times Y}$$

The numerical value of Y may be calculated for any gear provided certain basic factors are known :

(i) Tooth pressure angle
(ii) Number of teeth in the gear and pinion
(iii) The chosen load point.

The chosen load point is the highest position on the tooth profile at which the whole tangential load is taken by one tooth. Above this point more than one tooth is in contact, consequently the load is shared. It is at this position of the applied tooth load that the bending stress is greatest. The actual position of the chosen load point depends on the contact ratio which may be defined as the ratio of the length of the path of contact to the base pitch. (See Fig. 2).

Referring to Fig. 2 "r" is the maximum length of the path of contact for the two gears shown. The limits of "r" are the two addendum circles. P_0 is the base pitch and is the distance between two consecutive teeth at the tooth pressure angle. The constant ratio rc which for continuous tooth action should be unity or greater, is the ratio r/P_0. This is a theoretical condition which will give unsatisfactory tooth action if the true involute forms are retained. The teeth would operate satisfactorily under no load conditions but under load the tooth deflection would cause serious interference. If pinion tooth A and gear tooth B deflect under load, the gear tooth C would approach the pinion flank D too early causing gouging at the point. As a consequence, the theoretical involute form must be modified to allow for this deflection. If the gear rotations are reversed, the pinion tooth A would gouge the flank of gear tooth B. In the case of precision gears a controlled tooth modification is applied so that contact is maintained along the full active portion of the tooth profile, the amount of material being removed from the tooth being equal to the calculated deflection under the applied load. Thus full smooth contact is retained under full load. (Under light loads the conditions are not as favourable). Thus the length of tooth contact is retained as "r".

Controlled tooth modification is a costly procedure so in the case of industrial gears, what is known as "tip relief" is applied. This refers to a removal of metal from the tooth profile near the tip of the tooth. The amount removed is usually in excess of the anticipated deflection as pitch errors in machining have also to be allowed for. Consequently, it is impossible to anticipate the tooth action over the portion of the tooth that has been relieved. Therefore, for the purpose of computing "Y" it is assumed that tooth action ceases where tip relief begins. Teeth cut to British Standards are so modified that a contact ratio of unity exists, i.e., $r = P_0$. This of course applies to the condition of unloaded teeth. Under load a more favourable condition is achieved. Tip relief is usually built into the cutting tool so that when the teeth are cut, the teeth are automatically relieved. If, as is usual, the same cutting tool is used for the pinion and gear, an equal amount of tip relief is not achieved. In the case of a very small pinion and a large gear, it will be found that the pinion has almost no tip relief while the gear has almost the full amount worked into the cutting tool.

Pinions and gears for cranes are usually of such proportion that the gear receives the full amount of relief worked into the cutter and the pinion a much less amount. For the purposes of Y factor calculation, it can be assumed that full tip relief is applied to the gear. These conditions have been assumed and the chosen load point determined accordingly. (See Fig. 3.)

Fig. 3 illustrates the condition where gear tooth C is just about to become loaded. The load moving down the face of pinion A has just reached point S. Thus S is the chosen load point. Having made this determination the Y factor can now be computed. (See Fig. 4.)

Per inch of tooth face maximum bending stress

$$S_1 = \frac{Wn \cdot \cos\theta x}{y^2/6}$$

Maximum compressive stress

$$S_2 = \frac{Wn \sin\theta}{y}$$

Maximum tensile stress

$$= \frac{6Wn\cos\theta x}{y^2} - \frac{Wn \sin\theta}{y}$$

$$= Wn\left(6x\frac{\cos\theta - y}{y^2}\sin\theta\right)$$

but $Wn = Wt \sec\alpha$ when α = tooth pressure angle, therefore maximum tensile stress

$$Sb = \frac{Wt \sec\alpha}{y^2}(6x\cos\theta - y\sin\theta)$$

but $$Sb = \frac{Wt}{Y}$$

therefore

$$\frac{Wt}{Y} = \frac{Wt\sec\alpha}{y^2}(6x\cos\theta - y\sin\theta)$$

therefore $$Y = \frac{y^2\cos\alpha}{6x\cos\theta - y\sin\theta}$$

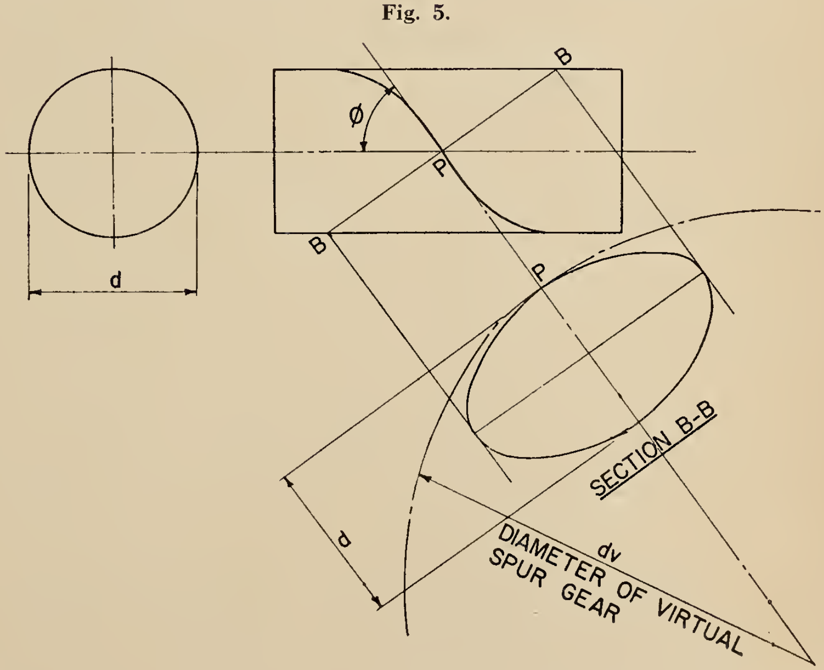
From an accurate layout of the tooth and this formula, Y can be calculated. It will be noted that the maximum tensile stress has been calculated rather than the greater maximum compressive stress, As gear teeth are designed on endurance considerations, it would not be reasonable to compute the compression stress as the more lightly stressed tension side would fail earlier by fatigue than would the heavily stressed compression side.

The Y factor for many combinations of teeth has been computed by the writer but the computations are long and tedious, as a tooth has to be accurately drawn for each combination of pinion and gear teeth. The values of Y that were computed were compared with values submitted by H. E. Merritt and since they corresponded fairly well, it has been decided to use Merritt's figures and graph the results.

For convenience a table of P/Y values for various diametral pitches and mating tooth numbers has been compiled.

Xb = SPEED FACTOR

Fig. 5.



Speed factors for strength will be identical with those for wear.

Sb = ALLOWABLE BENDING STRESS

The allowable bending stress will be based upon the endurance limit of the material but checked against the yield stress so that the factor of safety for yield will not be less than that for fatigue. Adopting as an allowable stress the least of 0.6 L.O.P. and 0.33 U.T.S., a factor of safety of 1.67 on both L.O.P. and fatigue is achieved, on the assumption of no stress concentration. (This is allowed for in the classification factor.) It will be noted, however, that the factor of safety of 1.67 is based upon the endurance limit value 0 – max. This applies to hoist gears for which the forces on the gear teeth do not reverse. When applied to travel gears the factor of safety is reduced to the approximate value (1.67/1.42) = 1.18 or 85% of the limit of endurance. The lower factor of safety is acceptable as it is unlikely that a tooth failure would result in any danger; moreover, the maximum tooth load on the gear is of short duration—during the period of acceleration only. During running, the tooth load is quite often no more than 30% of that corresponding to full load motor torque. Therefore Sb = 0.33 U.T.S. or 0.6 L.O.P. whichever is the least.

Required Face as Determined by Surface Stress Formula—F. This is the mini mum face that will carry the tooth load within the allowable surface stress for any given material.

Classification Factor — Cs

A tentative classification for crane structures has been drawn up with appropriate duty factors based on combinations of "working period", "effective load" and "impact".

However, when considering gear classification, it becomes evident that the factors cannot be applied as for structures. For example, the element "working period" for structures has two values, "short" and "long" according to whether the duty of the crane can be expected to impose stress cycles of less or more than 2×10^6 in the life of the crane. For each stress cycle imposed on the crane structure, many stress cycles will be imposed on the pinion and gear teeth and fatigue in those items is definitely the criterion of allowable stress. All gears, therefore, will be considered as subjected to long working period and the structural element of 1.34 assigned.

Similarly, the element "effective load" must always be taken as "high"—again on the basis of fatigue, as, although the number of occasions when full rated load is handled in unit time may be quite small with respect to the structure, it becomes a significant proportion when considering the gears. The value for this element will be taken as 1.0, as for structures.

Impact, the third element, corresponds to impact on the structural parts as it is of transient and practically instantaneous nature. Two values for impact are therefore used –1.10 for low impact and 1.40 for high impact. Table 8 shows the combinations of these values for each classification and the factors to be used.

Summary of Design Procedure — Spur Gears

1. Determine ratio and probable gear and pinion diameters.
2. Apply surface stress formula to determine face width.

$$F = \frac{W \cdot Cw}{Xc \cdot Sc \cdot Q}$$

F = face (in.)
W = tooth load (lbs.)
Q = surface form factor
Xc = Speed factor
Sc = Surface Stress factor
Cw = Classification factor
Class A — 0.5 Class C — 0.8
Class B — 0.6 Class D — 1.0

3. Apply the strength formula

$$\frac{P}{Y} = \frac{Xb \cdot Sb \cdot F}{W \cdot Cs}$$

Xb = Speed factor = Xc
Sb = Allowable bending stress
F = Face width obtained from surface stress formula
Cs = Classification factor
Class A — 1.5 Class C — 1.9
Class B — 1.9 Class D — 1.9
(P/Y) = strength factor

HELICAL GEARS

General: The method of design of Helical Gears is similar to that employed for spur gears because the normal section of a helical gear tooth is the same as that of a spur gear tooth. For design purposes it is convenient to assume a virtual spur gear having teeth of the same size and shape as the normal section of a helical gear. The load carrying characteristics of such a virtual spur gear bear a definite relationship to the actual helical gear. Therefore by applying the spur gear method of design to the virtual spur, the load carrying characteristics of the actual helical gear can be readily determined.

Virtual Spur Gear: Section *P–P* Fig. 5 (a section through the helical gear normal to the teeth) is an ellipse having a minor diameter d the same as the gear diameter and a major axis = $d \sec \phi$ when ϕ is the tooth helix angle. It can be proved that in the region of the pitch point P the curvature of the ellipse approximates to that of a circle of radius d_v and it may be shown that:

$$d_v = d \sec^2 \phi$$

$$t_v = t \sec^2 \phi$$

where
d = helical gear P.C.D.
t = number of teeth in helical gear
d_v = Virtual gear P.C.D.
t_v = number of teeth in Virtual gear

Helical Gear Form Factor: (See Fig. 6)
(a) Length of line of contact for one axial pitch

total length $= hb + gf = 1$
but $gf = bk$
therefore $1 = hk$
Triangles mhk and ahb are similar

therefore $\frac{mk}{hk} = \frac{ab}{hb}$

but $hb = pa \sec \phi$
$mk = p_{0t} \times r_{ct}$
$hk = 1$
$ab = p_{0t}$

therefore $1 = \frac{p_{0t} \cdot r_{ct} \cdot p_a \sec \phi}{p_{0t}}$

but $r_{ct} = r_{cn} \cos^2 \phi$

therefore $1 = r_{cn} p_a \cos \phi$

Length of line of contact per inch of face
$1_l = r_{cn} \cos \phi$

(*Note:* This is not the full developed length but the error is negligible.)

(b) Load on face of virtual spur gear. Tangential load per inch of face on helical gear W_t
Tangential load on virtual spur $= W_t \sec \phi$
Load on virtual spur at chosen load point $= W_t \sec \phi \cos \theta = W_n$—Fig. 4.

(c) Maximum intensity of load at chosen load point of virtual spur.

Table VIII. Strength Classification Factors

Class	Working Period	Effective Load	Impact	Classification Factor (calculated)	Actual Factor to be used
A	Long 1.34	High 1.0	Low 1.1	1.47	1.5
B	Long 1.34	High 1.0	High 1.4	1.88	1.9
C	Long 1.34	High 1.0	High 1.4	1.88	1.9
D	Long 1.34	High 1.0	High 1.4	1.88	1.9

Referring to Fig. 4.

$$\text{Average intensity of load} = \frac{Wn}{1} = Wc$$

therefore

$$Wc = \frac{Wt \sec\phi \cos\theta}{r_{cn} \cos\phi} = \frac{Wt \sec^2\phi}{r_{cn}} \cos\theta$$

For industrial gears with tip relief it is assumed that ratio of contact r_{cn} = unity. therefore

$Wc = Wt \sec^2\phi \cos\theta$ = maximum intensity, as a constant load over one base pitch is assumed.

Therefore tangential intensity of load on virtual spur $= Wt \sec^2\phi = Wt_v$.

(d) Form Factor

$$Sb_v = \frac{Wt_v}{Y_{vs}} = \frac{Wt \sec^2\phi}{Y_{vs}}$$

but

$$Sb \text{ helical} = \frac{Wt}{Y_{\text{helical}}}$$

Since

$$Sb_v = Sb \text{ helical}$$

$$\frac{Wt \sec^2\phi}{Y_{vs}} = \frac{Wt}{Y_{\text{helical}}}$$

therefore

$$Y \text{ helical} = \frac{WtY_{vs}}{Wt \sec^2\phi} = Y_{vs} \cos^2\phi$$

Note this expression is based upon and is similar to that developed by Merritt. However, Merritt assumes that the transverse D.P. is an integer whereas the above assumes that the normal D.P. is an integer in line with our standards.

Thus in order to determine the Y factor for a helical gear it is necessary to

(i) Determine the number of teeth in the virtual spur gear
$t_{vs} = t \sec^2\phi$

(ii) Find the Y factor for the virtual spur (Y_{vs})

(iii) Apply the formula
$Y = Y_{vs} \cos^2\phi$
to determine the helical gear form factor

where ϕ is the helix angle of the helical gear.

Helical Gear Surface Form Factor—Q as for spur gears $Q = (Z/p)$.

It can be proved that

$Z(\text{helical}) = Z_{vs} \cos^2\phi$

so Q can be calculated in a similar manner to Y (helical), viz:

(i) Determine the number of teeth in the virtual spur gear
$t_{vs} = t \sec^2\phi$

(ii) Find Z_{vs}

(iii) Apply the formula
$Z = Z \cos^2\phi$
to determine the helical gear zone factor

(iv) $Q = (z/p)$

where

z = Helical zone factor
p = Normal diametral pitch.

Helical Gear Speed Factor: The dynamic effects in helical gears, due to tooth error differ little from those for straight spur gears. However, built in to the straight spur speed factor $1 - (\sqrt{V}/50)$ is a face factor to allow for mal-alignment of gears. In the case of helical gears this would appear to be unnecessary.

While the tip relief has no shortening effect on the line of contact in the case of spur tooth, it results in considerable shortening in the case of a helical tooth, the effective length being "l"—Fig. 3b. Allowance is made for this effect in the determination of the load carrying characteristics of the tooth. However, mal-alignment will tend to cause severe unevenness of stress distribution along the line of contact of a straight spur and if tooth deflection is insufficient to compensate, an actual shortening of the line of contact; the effect on helical teeth is less severe as points a and b will tend to move to points a_1 and b_1 respectively keeping l_1 approximately equal to l. Thus although some lack of uniformity of stress distribution may be experienced, there is little likelihood of a shortening of the path of contact.

Therefore it has been decided to omit a face factor and base the speed factor on the well tried expansion.

$$x = \frac{900}{900 + v}$$

Fig. 7 shows the curves for straight spur speed factor and helical speed factor. It will be noted that the curves become more divergent as the speed increases. This is logical as normally it will be found that the higher the speed, the less the load per inch of face and therefore the less the compensating deflection to offset the affect of mal-alignment. Thus it may be reasoned that the higher the speed, the more the necessity for a face factor.

Summary of Design Procedure — Helical Gears

Helical gears will be designed in a manner similar to that employed for straight spur gears.

It can be shown that for helical gears having a small helix angle, Qh and Yh differ little from Q and Y for spur gears. Therefore it is suggested that helical gears having a helix angle *not greater than* 15° be designed as if they were spur gears with the exception that Xh be substituted for X.

1. Determine the ratio and probable gear and pinion diameters.

2. Apply the surface stress formula to determine the minimum face width.

$$F = \frac{W \cdot Cw}{Xh.Sc.Q}$$

where

W = tooth load (lb.)
Cw = classification factor as for spur gears
Xh = speed factor $= 900/(900 + v)$
Sc = surface stress factor—as for spur gears
Q = surface form factor.

3. Apply the strength formula

$$\frac{P}{Y} = \frac{Xh \cdot Sb \cdot F}{W \cdot C_s}$$

where

P = normal diametral pitch
Y = strength form factor (Helical)
Xh = speed factor $= 900/(900 + v)$
Sb = allowable bending stress as for spur gears
F = face width obtained from surface stress formula
Cs = classification factor as for spur gears.

Table 9 is a small section of the table of values of the strength factor P/Y.

It must be understood that the values shown in Table 9 apply only to Dominion Bridge standard gears. Any other gear system which embodies differences in either (a) tooth depth, (b) pressure angle, (c) addendum modification or (d) employs a helix angle greater than 15 , would require that the values ofr Q and P/Y be calculated as proposed in the text.

In order to illustrate the design procedure outlined, a few examples are appended:

Example 1. Drum gear and pinion for a 250-ton hoist motion Class A, spur gears, open, grease lubricated, Gear 45.6 in. p.c.d. material 0.40 carbon steel heat treated to 200-225 B.H.N.
Pinion 13.6 in. p.c.d. material SAE 3140 heat treated to 240-265 B.H.N.
Ratio = 3.35 to 1.
Tangential tooth load 52,000 lb.
Pitch line velocity 65 f.p.m.

Table IX. P/Y Values

Teeth in Pinion	Teeth in Gear: 1 D.P. 40 & over	1¼ D.P. 40 & over	1½ D.P. 40 & over	1¾ D.P. 40 & over	2 D.P. 40 & over	4 D.P. 40 & over	5 D.P. 40 & over
11						8.73	
12						8.48	
13	2.07					8.28	
14	2.00						10.0
15	1.94						9.70
16		2.39					9.54
17		2.35					
18		2.31					
19			2.74				
20			2.70				
21			2.69				
22							
23				3.08			
24				3.05			
25				3.03			
26					3.44		
27					3.42		
28					3.40		

Durability

X (speed factor) = 0.84
Sc = 2300 (softer of pair)
Q = 1.54
C_w = 0.6 (open gears)

Min. face width required

$$F = \frac{T \cdot Cw}{X \cdot Sc \cdot Q} = \frac{52{,}200 \times 0.6}{0.84 \times 2300 \times 1.54} = 10.55 \text{ in.}$$

(make 11 in.)

Strength

Face Width F = 11 in.
S_b = 0.33 × 100,000 = 33,000 p.s.i.
or = 0.60 × 77,000 = 46,500 p.s.i.
C_s = 1.5

$$\frac{P}{Y} = \frac{0.84 \times 33{,}000 \times 11}{52{,}200 \times 1.5} = 3.89$$

From table $\frac{P}{Y}$ for 27 teeth 2 dp is 3.42,
for 24 teeth $1\frac{3}{4}$ dp is 3.05
for 20 teeth $1\frac{1}{2}$ dp is 2.70
for 17 teeth $1\frac{1}{4}$ dp is 2.35
for 14 teeth 1 dp is 2.00

Any of these pinions would therefore satisfy strength requirements.
Example 2.

Intermediate hoist gear and pinion
Class B—helical, enclosed in oil-bath gearcase

Gear 20.45 in. p.c.d. material alloy steel heat treated to 360-390 B.H.N.

Pinion 3.88 in. p.c.d. material as for gear
Ratio = 5.27 to 1

Tangential tooth load = 8530 lb.
Pitch line velocity = 455 f.p.m.

This represents 120 H.P. at 870 r.p.m. at input shaft of gearcase.

Durability

X = 0.664 Q = 0.48
S_c = 4500 C_w = 0.6

Min. face width required

$$= \frac{T \cdot Cw}{X \cdot S_c \cdot Q} = \frac{8530 \times 0.6}{0.664 \times 4500 \times 0.48} = 3.57 \text{ in.}$$

(make 4 in.)

Strength

F = 4 S_b = 53,000 C_s = 1.9

$$\frac{P}{Y} = \frac{X \cdot S_b \cdot F}{T \cdot C_s} = \frac{0.664 \times 53{,}000 \times 4}{8530 \times 1.9} = 8.68$$

From table P/Y for 12 teeth 4 dp is 8.48. This is correct choice as 12 teeth is minimum standard and 12/D.P. = 3 in. for overlap, so the face width of 4 in. is ample. If F had been made $3\frac{3}{4}$ in. P/Y would have become = 8.15 and 12 teeth 4 dp would not satisfy this.
Note: When using Table 9 the tabulated value of P/Y for the pinion selected must never exceed the calculated value.
Example 3.

Consider the effect of changing the classification of the pinion and gear in example 2, assuming that the pitch line velocity remains constant.

Change Classification to A
Durability:

Allowable tooth load

$$= 8530 \times \frac{4}{3.57} \times \frac{0.6}{0.5} = 11{,}500 \text{ lb.}$$

Strength:

Allowable tooth load

$$= \frac{0.664 \times 53{,}000 \times 4}{8.48 \times 1.5} = 11{,}100 \text{ lb.}$$

This illustrates a case in which strength considerations govern the capacity of the pair and shows that for class A, the equivalent input of the gearcase can be raised as regards the intermediate reduction to 156 H.P. at 870 r.p.m.

Change Classification to C
Durability:

Allowable tooth load

$$= 8530 \times \frac{4}{3.57} \times \frac{0.6}{0.8} = 7180 \text{ lb.}$$

Strength:

Allowable tooth load

$$= \frac{0.664 \times 53{,}000 \times 4}{8.48 \times 1.9} = 8730 \text{ lb.}$$

This gives an equivalent input of 101 H.P. at 870 r.p.m.

Test

Unfortunately, space limitations make it impracticable to give a full description of the test carried out as a check on the above design methods. A brief note of the procedure and its results will have to suffice.

A test gear case was built consisting of one reducing gear and one increasing gear, each with a ratio of 7.17 to 1 so that the output shaft ran at the same speed as the input shaft. The input shaft was coupled to a 125 h.p. at 1800 r.p.m. electric motor and the output shaft drove a hydraulic dynamometer which provided wide adjustments of torque.

The gears were designed for 79 h.p. at 1780 r.p.m. class A and were made from heat-treated alloy steel. The teeth were cut after heat-treatment and were given a rather poor finish even for industrial gears. All bearings were rolling type and an extreme pressure lubricating oil was used with splash lubrication.

The duration of the test was as follows:

(a) Run for 30 minutes at 5 hp.
(b) Run for 4 hours 50 mins. at 25 hp.
(c) Run for 5 hours at 50 hp.
(d) Run for 21 hours at 75 hp. Stop and inspect at 4 hr. intervals.
(e) Run for 150 hours at 98 hp. Stop and inspect at 4 hr. intervals.
(f) Run for 3 minutes at 148 hp.
(g) Run for $1\frac{1}{2}$ minutes at 175 hp.

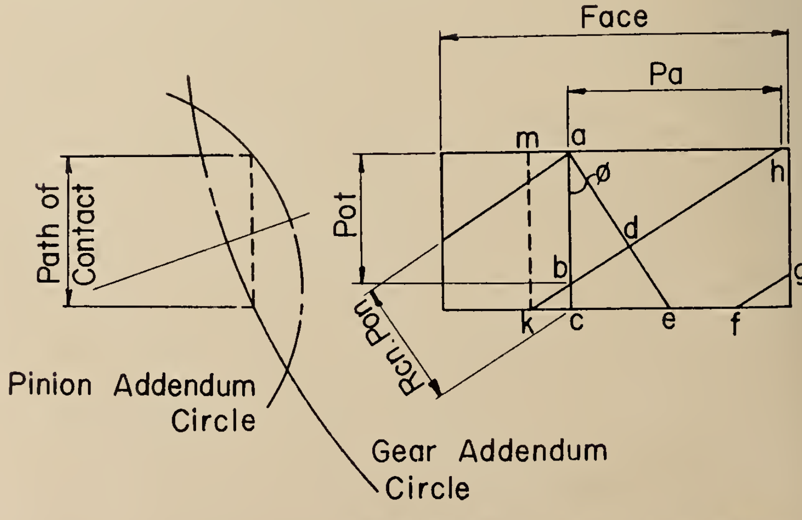
These running periods were calculated to be equivalent to a total of 500 hr. at full rated load and gave approximately 18 × 10^6 load cycles on the pinion teeth.

Results:

After (a) slight scuffing appeared on the output pinion teeth.

After (b) scattered pitting was observed on both gears and a narrow band of pitting showed at the pitch line of the input pinion teeth.

Fig. 6.



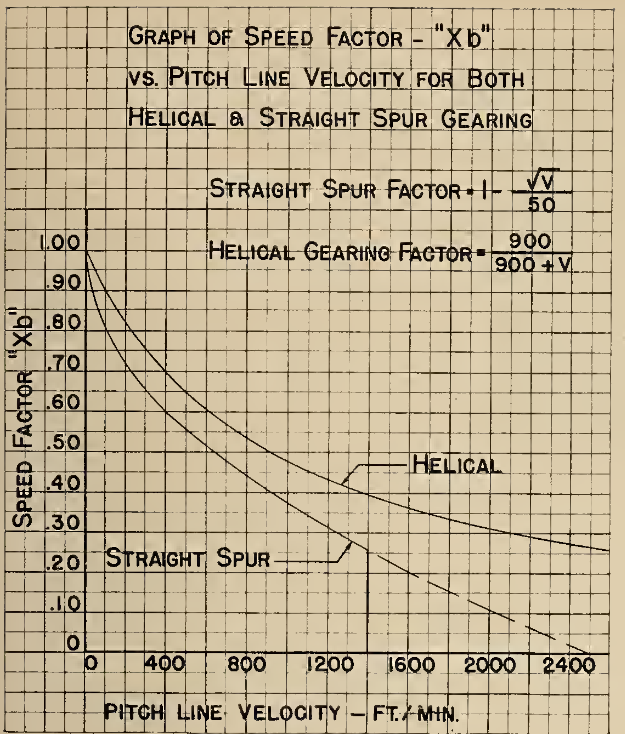


Fig. 7.

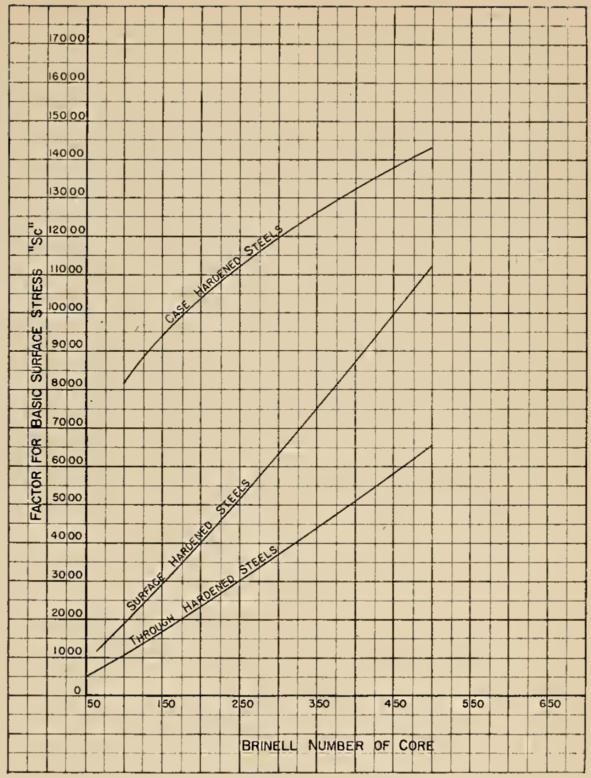


Fig. 8. Approximate Basic Stress Factors.

After (c) pitting had increased on the gears. Heating of the oil became very marked.

During (d) the pinions rapidly acquired a uniform polish and the tool marks disappeared with a small increase in the amount of pitting but with no observable increase in depth. The pitting on the gears spread slowly across the teeth. For the last 17½ hr. of this stage, change in pitting was very slow.

During (e) inaccuracies in the dynamometer were detected and a watt meter was connected in the motor circuit as a check. After this was done, the input was kept steady at 98 hp. whereas for the first 8 hr. of this stage it had varied up to a value of 120 hp.

No radical changes appeared for 118 hours of this stage but subsequently the tip relief area of the pinion teeth showed heavy wear and burring appeared at the tips. Pitting increased and both pinion and gear teeth showed undercutting at the pitch lines.

After (d) and (e) no apparent change was observed but on final dismantling some weeks later, two teeth had broken on the input pinion, the nature of the fractures being typical of fatigue failure.

Although the results of the test may appear unfavourable at first glance, it is felt that the design method has been proved satisfactory for the following reasons :

(a) The finish of the gear teeth was poor. Tooth errors were present much in excess of those to be expected from industrial quality cutting. Therefore a large increment of dynamic loading certainly existed. High local surface stresses would contribute to the early pitting.

(b) The high ambient temperatures experienced during the test (on most days exceeding 90°F.) precluded much natural cooling. Oil temperatures were consistently high and although subsequent analysis of the oil showed no breakdown, lubrication must have been affected.

(c) Dynamometer inaccuracies undoubtedly imposed higher loads than expected, at least for part of the test.

(d) Continuous running periods of 4 hours under full load could never be realized on a class A crane and indeed would only be experienced on a class D or mill crane and then only on the bridge travel motion. The heating aspect then could not normally be experienced on crane drives.

General: The above design method is not expected to supplant existing methods for all applications of gearing but is put forward as a logical basis for design of gears in such applications as cranes where the economics of material and labour costs plus weight saving have to be offset against design costs. It is also realized that the investigation, while fairly exhaustive, has only been carried to a point which would indicate that existing criteria were suitable and, this having been established, these criteria have been accepted as reasonable, without attempting to prove or disprove their derivation. Furthermore, although the introductory remarks on Spur Gears point out that tooth deflection may affect face width, no attempt has been made to set up limits for such deflections. The fact that, in the case of spur gears, a face factor has been embodied in the speed factor (Xc) is considered to cover this, while for helical gears, the requirements of overlap very often require a face width greater than that determined by surface stress considerations.

In conclusion, the writer wishes to acknowledge the very valuable contribution made by Mr. A. C. Briggs now of Dravo Corporation, Pittsburgh, Pa., U.S.A., who made the investigation and report which formed the body of this paper. Mention should also be made of the work of Mr. S. F. Angus, Jr., E.I.C.,
the work of Mr. S. F. Angus, Jr. E.I.C.,
who made the lengthy calculations for Table 9.

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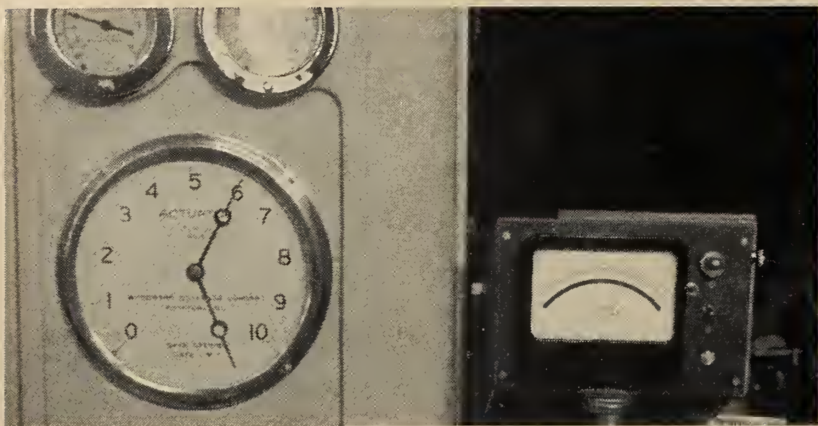
OPTIMUM ADJUSTMENT of GOVERNORS



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IN HYDRO GENERATING STATIONS

This paper discusses the elementary theory of speed governing, and differential equations are derived in the Appendix together with the main parameters involved in the speed transient of a turbine following a load change and what settings should be recommended for optimum response. As all generating stations are tied together by relatively stiff electrical connections, a method of setting up the governors of each machine will be described which assumes that all machines behave as one equivalent. Methods will be described as to how the primary and secondary compensation can be simply measured in the field and how each is adjusted to a selected value.

THE MANITOBA Hydro-Electric Board supplies the bulk of power to the Province of Manitoba from 4 hydro-electric plants on the Winnipeg River. These stations are tied in with two other plants on the same river which are owned and operated by The City of Winnipeg Hydro-Electric System. The total rated capacity of all these stations is in the order of 585 Mw and, with the exception of one 75 Mw station, consists of conventional vertical machines with prime movers of the fixed blade propeller type. The stations are all of medium head range with short intakes to the turbines.

At the present time there is an interconnection with the Northwestern system of The Hydro Electric Power Commission of Ontario which is also a predominantly hydro system with a number of stations located in the area between the Ontario-Manitoba Boundary and the lake head at Fort William. The generating capacity of this system is somewhat less than the Manitoba System.

The Board has recently brought into operation the Brandon thermal plant of 120 Mw and is at present constructing another thermal station at Selkirk having an initial capacity of 120 Mw.

From the above it can be seen that the integrated system is predominantly hydro and the problem of setting up the governors for optimum performance has occupied our attention over the last few years, particularly since the combined systems are not what could be termed a large system where transient governing problems might be considered of less importance.

The main difficulty with speed governing on an hydraulic turbine is the effect of the water inertia which introduces an unstabilizing effect on the steady state speed unless the governor is provided with a very large temporary speed droop. The water inertia effect tends to increase the turbine output during wicket gate closure and decrease it on gate opening. The effect is therefore just opposite to what the governor tries to do when a speed change occurs. If we try to overcome this effect by decreasing the temporary speed droop then the machine becomes unstable and continues to oscillate about an average speed which, of course, is an impossible operating condition.

As will be shown later, and developed in the Appendix, if the governor is provided with a large temporary speed droop together with a dashpot which will slowly decrease the droop with time, the governor and machine can be made completely stable.

It might be of interest to note that with a steam turbine governor the time lags associated with this type of machine make it possible to operate stably with 0.04 to 0.05 p.u. speed droop and with these small values, it is not necessary to provide a dashpot whereas with an hydraulic turbine, values of temporary droop have to be in the order of 0.20 to 1.0 p.u. to give stable operation.

It can be seen that with such a high temporary droop there will be a relatively large momentary deviation in speed following a load change which will be corrected by the action of the dashpot after a time interval.

The following analysis attempts to show what selection of parameters should be used on such a governor to give the following:

1. Minimum speed deviation after load change;
2. Quick return to normal speed;
3. Adequate stability of governing.

Before proceeding with detailed discussion on hydro governing, reference should be made to the last part of the Appendix which shows mathematically why any governor will hunt or be unstable unless speed droop or some other form of compensation is applied. This latter analysis is more closely applicable to steam turbine governing where the rate of valve movement and trapped steam are the unstabilizing element.

The following analysis of hydro governors is mostly concerned with the transient response characteristics and the adjustments which have to be made to give optimum performance during load swings. It is realized that dead band and friction can materially affect the performance of such a governor for steady state operation. These latter conditions are not too significant for transient performance.

In setting up the differential equation of performance, the following assumptions are made:

1. The steady state speed droop which is about 0.035 p.u. is neglected;

2. The turbine is operating at around the point of maximum efficiency where any change in input torque is closely proportional to the corresponding change in gate position;

3. The change in speed is relatively small say ±0.10 p.u. so that the nonlinear relationships can be linearized

and the gate velocity does not reach its saturation value;

4. The net damping torque at the turbine shaft as a function of load torque and turbine torque is zero. This condition is approximately equivalent to an A.C. generator with a voltage regulator supplying a purely resistive load;

5. The time constant between the pilot valve movement and main servo can be neglected;

6. That for purposes of setting the governors on a multi-machine system the values of water starting time Tw and mechanical starting time Tm can be weighted for the group in such a manner that the group will behave as a single equivalent machine;

7. That the mechanical inertia of all rotating loads is neglected.

It is felt that the above assumptions are somewhat on the conservative side, particularly as regards the damping effect. However, excellent results have been achieved in using the above assumptions, working out the main equations, and setting up the adjustable parameters which result.

Stemming from the above assumptions the main differential equations involved are as follows:[1]

Machine acceleration

$$Tm\frac{dn}{dt} = g + 1.5h - \Delta M \qquad (1)$$

Water acceleration

$$-0.5Tw\frac{dh}{dt} = Tw\frac{dg}{dt} + h \qquad (2)$$

Governor response

$$-\delta Tr\frac{dg}{dt} = Tr\frac{dn}{dt} + n \qquad (3)$$

Where

n = Relative per unit instantaneous speed
h = Per unit instantaneous head
g = Per unit instantaneous gate
ΔM = Per unit step load torque change
Tm = Mechanical starting time, seconds
Tw = Water starting time, seconds
Tr = Dashpot relaxation time constant, seconds
δ = Temporary speed droop

δ and Tr are known as primary and secondary compensation respectively[5]. As we are mainly interested in the speed change following a load change, the variables h and g can be eliminated and the following differential equation of n can be written

$$0.5\delta TrTmTw\frac{d^3n}{dt^3} + (\delta TrTm - TwTr)\frac{d^2n}{dt^2} + (Tr - Tw)\frac{dn}{dt} + n = 0 \qquad (6)$$

See Appendix for derivation of equations (1), (2), (3), and (6).

The equation (6) represents continuous oscillatory or damped functions of n with time t and the Routh-Hurwitz criterion for stability is that

$$0.5\,\delta TrTmTw > 0,$$

$$(\delta TrTm - TwTr) > 0 \quad (Tr - Tw) > 0$$

$$(Tr - Tw)(\delta TrTm - TwTr) > 0.5\,\delta TrTmTw$$

From these conditions it can be seen that if Tr is less than Tw we could have instability.

Typical values of these parameters for a short intake plant could be

$$Tm = 9$$
$$Tw = 1.2$$
$$Tr = 5$$
$$\delta = 0.30$$

As shown in the Appendix and Fig. 2 various degrees of stability can be maintained for various values of the ratios Tw/Tr and $Tw/\delta Tm$, but if any of these values fall outside the boundary of the curve (Fig. 2) instability can result.

Analog computer studies[1] have been made for various values of the above ratios and a plot of the resulting speed transients is shown on Fig. 2. Note that as the boundary curve is approached the speed transient becomes more oscillatory. These were taken for step load changes.

Several authorities[1,12] have indicated that an optimum speed transient results when $Tw/Tr = 0.2$ and $Tw/\delta Tm = 0.5$ or $Tr = 5Tw$ and $\delta = 2Tw/Tm$. However, for setting up the governors on the Winnipeg River generating stations we have selected the ratios

$$Tw/Tr = 0.25 \qquad Tw/\delta Tm = 0.5$$

$$\text{or} \quad Tr = 4Tw \qquad \delta = 2Tw/Tm$$

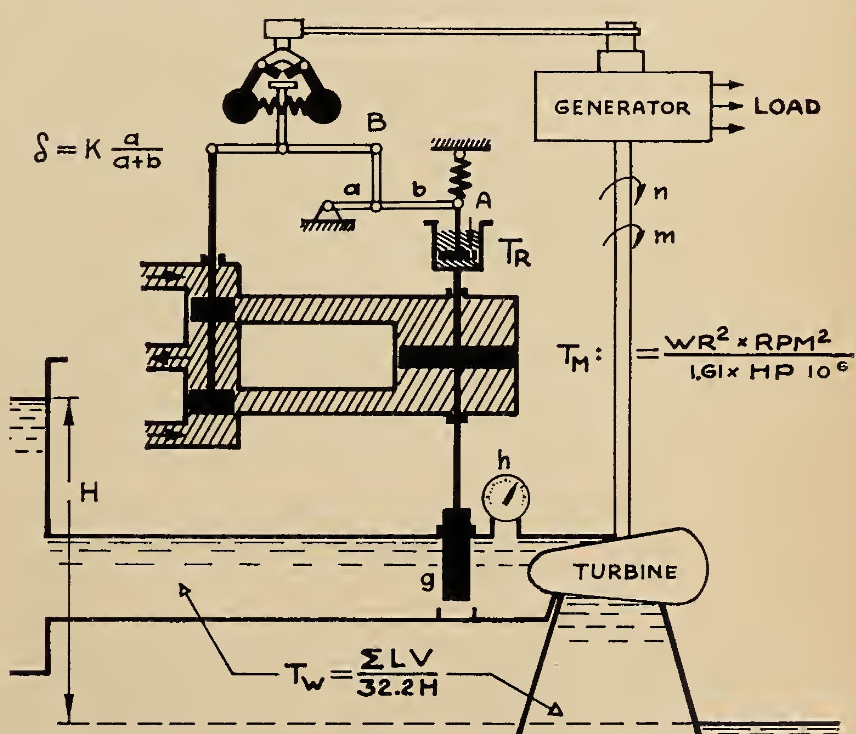
The computed speed transient resulting from inserting the above parameters in equation (6) is shown in Fig. 5.

Fig. 1 shows diagramatically a typical water wheel generating unit and its governor together with the significant parameters which affect governing.

The fixed parameters are Tw and Tm for the particular machine and only δ the temporary droop and Tr the dashpot relaxation time constant are each adjustable. The temporary droop is adjusted by changing the lever ratio $a/(a + b)$. The dashpot relaxation time constant is adjustable by means of the needle valve opening shown in the sketch as a small hole in the dashpot piston.

Fig. 6 shows the internal construction of a familiar actuator type governor used on this continent. The temporary droop is adjusted by selecting certain hole combinations on the top and bottom floating levers, and close adjustments are finally made by altering the throw of the eccentric which drives the large dashpot piston. These adjustments can only be made when the machine is shut down or on hand control.

Fig. 1. Sketch showing hydraulic turbine and generator with typical governor.



The needle valve opening can be altered with the machine on the line and Fig. 3 shows the general arrangement on this type of dashpot.

As there are no calibration marks on this type of actuator indicating the values of temporary droop and dashpot time the following procedures were developed for measuring these quantities.

To measure the temporary droop the machine is off the line and running on governor control at speed no-load. An accurate tachometer is set up beside the governor pedestal. With the dashpot needle valve open about one-eighth of a turn, control is taken away from the governor head by using the gate limit (red pointer) to depress the speed by 0.10 p.u. or down to 54 cycles. When the speed is steady at this point the needle valve is closed tight and a reading of the gate dial opposite the black pointer is recorded. The gate limit now is suddenly removed, which puts the machine back on governor control, and as there is a 0.10 speed error below rated speed the gates suddenly open and momentarily stop at some position up scale on the gate dial. This point is recorded. Due to water inertia the actual speed of the machine does not change perceptibly during this gate transient so we have a measure of temporary droop in accordance with the following relationship:

$$\delta = \frac{0.10}{c - d}$$

where

c = Reading on gate dial where motion momentarily stops.

d = Initial reading on gate dial to hold speed 0.10 p.u. below normal.

For example, if c equals 0.2 gate and d equals 0.4 gate we have

$$\delta = \frac{0.10}{0.4 - 0.2} = 0.50 \text{ p.u.}$$

By making successive tests, each time altering the lever ratio, we arrive at the selected value of temporary droop. Note that with needle valve closed, temporary droop is theoretically permanent.

In making this measurement care should be exercised to be certain that the small dashpot piston does not bypass as this will give a false reading. This difficulty may be overcome by taking a smaller speed interval.

As the speed no load point on a propeller wheel is about 0.3 p.u. gate the temporary droop selected from the governor equation is modified for purposes of measurement in the following manner:

Let δ = Droop from equations

Let f = p.u. speed no load gate position

Measured Droop = $\delta/(1 - f)$

For example, if δ = 0.33 and f = 0.33

Measured droop should be

$$0.33/(1 - 0.33) = 0.50 \text{ p.u.}$$

To measure the dashpot relaxation time constant Tr for a given needle valve opening refer to Fig. 3. The former shows the setup diagramatically, together with the exponential characteristic, and the latter shows the actual arrangement used for carrying out this measurement. The actual measurement of Tr is carried out with the machine shutdown or on hand control by manually depressing the small dashpot piston until the pointer is a little above the 1.00 figure. It is now released and as the pointer passes the 1.00 figure a stop watch is started and as the pointer comes opposite the figure 0.37 the stop watch is stopped and the time interval read. This is Tr in seconds for the particular needle valve setting. This measurement is repeated for the opposite direction and a relationship is found for Tr as a function of various needle valve openings. As a rule, it is found that the needle valve opening is very critical for a given Tr. Needle valve opening is recorded in fractions of turns.

Outline of Basis for Setting Winnipeg River Governors

As stated earlier in this paper weighted averages of Tm and Tw for all machines are used for purposes of arriving at a common temporary droop and dashpot time for each machine. Table I gives the ratings of all groups of similar machines with the individual Tm and Tw for each group.

From Table I Weighted average

$$Tm = \frac{4{,}617{,}000}{783{,}000} = 6.00 \text{ seconds}$$

From Table I Weighted average

$$Tw = \frac{778{,}000}{783{,}000} = 0.99 \text{ seconds}$$

The above figures are rounded off to

$$Tm = 6 \text{ seconds}$$

$$Tw = 1 \text{ second}$$

From the appendix it will be noted that the selected optimum settings of temporary droop and dashpot time are

$$\delta = 2Tw/Tm \qquad Tr = 4Tw$$

which gives

$$\delta = 2 \times 1/6 = 0.333 \text{ p.u.}$$

$$Tr = 4 \times 1 = 4 \text{ seconds}$$

Since most of the machines have a speed no load point under average head condition of about 0.333, the corrected temporary droop for measurement purposes is

$$\delta = \frac{0.333}{1 - 0.333} = 0.50 \text{ p.u.}$$

For measurement purposes all machines have therefore been set at the following values using measurement methods as outlined above.

$$\delta = 0.50 \text{ p.u.} \qquad Tr = 4 \text{ seconds}$$

Operating results with these settings have been very successful up to now although instability was experienced at Seven Sisters which turned out to be due to worn dashpot pistons. This problem was temporarily overcome by using a heavier oil in the dashpots until such time as they could be repaired.

No attempt is made to reduce the dashpot time constant below 4 seconds for on load conditions. However, this value is sometimes increased manually while a machine is being synchronized, but is put back to normal after the circuit breaker is closed. The normal frequency fringe for the system just under ±0.1 of a cycle.

Conclusions

1. Methods are now available which make it possible to predetermine governor settings. While it is realized that certain assumptions are made in order to simplify the mathematical approach it is felt that the application of the method as outlined has resulted in improved transient response on the combined system.

2. Adequate measuring techniques have been developed so that the computed values of dashpot relaxation time Tr and the temporary droop δ can be applied to a governor without having to guess or calculate the position of these adjusting devices.

Table I

Station	*H.P.*	*Tm*	*H.P.* × *Tm*	*Tw*	*H.P.* × *Tw*
Seven Sisters	113,000	7.35	830,000	0.77	87,000
Seven Sisters	112,000	6.79	760,000	0.77	87,000
Slave Falls	96,000	6.55	630,000	1.30	125,000
McArthur Falls	80,000	3.95	317,000	1.47	118,000
Great Falls	168,000	5.10	860,000	0.85	143,000
Pine Falls	114,000	6.31	720,000	1.47	168,000
Pointe du Bois	100,000	5.00	500,000	0.50	50,000
Totals	783,000	—	4.617×10^6	—	778,000

Acknowledgement

I would like to acknowledge with thanks the co-operation of the Operating Divisions of The Manitoba Hydro-Electric Board and City of Winnipeg Hydro-Electric System who made equipment available for tests and arranged for the installation of the necessary measuring equipment.

Appendix

Derivation of Mechanical Starting Time Tm of Machine: This parameter may be defined as the time in seconds required to accelerate the machine from zero reference speed to rated speed with rated torque applied.

The differential equation of motion of the revolving mass is

$$I\frac{d^2\theta}{dt^2} = Mg \qquad \text{(a)}$$

where

I = WR^2 = Moment of inertia of rotating elements lb. ft².

M = Rated torque of machine in lb. ft. corresponding to rated HP. at rated speed r.p.m.

g = Acceleration due to gravity 32.2 ft.sec².

$d^2\theta/dt^2$ = Angular acceleration in radians per sec. per sec.

Integrating equation (a) once we have

$$I(d\theta/dt) = Mgt + k$$

when $t = 0$, $d\theta/dt = 0$

$$\therefore \qquad k = 0$$

Substituting WR^2 for I and 32.2 for g, we have

$$\frac{WR^2}{32.2}\frac{d\theta}{dt} = Mt \qquad \text{(b)}$$

By definition $t = Tm$, when $d\theta/dt$ = rated speed, and M = rated torque. Under these conditions

$$\frac{d\theta}{dt} = \frac{2\pi \cdot \text{RPM}}{60} \text{ radians per second}$$

and $2\pi\text{RPM} \cdot M = \text{HP} \times 33{,}000$

$$\therefore \qquad M = \frac{\text{HP} \times 33{,}000}{2\pi\text{RPM}}$$

Substituting these relations in equation (b), we have

$$\frac{WR^2}{32.2} \times \frac{2\pi\text{RPM}}{60} = \frac{\text{HP}33{,}000}{2\pi\text{RPM}} \times Tm$$

$$\therefore \quad Tm = \frac{WR^2 \times 4\pi^2 \times \text{RPM}^2}{32.2 \times 60 \times \text{HP} \times 33{,}000}$$

$$Tm = \frac{WR^2 \times (\text{RPM})^2 \times 10^{-6}}{1.61 \times \text{HP}}$$

If we call n = per unit rated speed
m = per unit rated input torque

we can rewrite the acceleration equation using Tm as follows:

$$Tm\frac{dn}{dt} = m$$

here dn/dt is expressed in per unit speed change per second.

If we integrate this equation once

$$Tmn = m \cdot t + c$$
$$c = 0 \text{ when } n = 0$$

and substituting $n = 1$ and $m = 1$

$$\therefore Tm = t \text{ as per definition.}$$

The application of these normalized or per unit quantities simplifies the analysis considerably. Note that if we substitute Kw for HP. and divide by 2 we obtain the familiar inertia constant H used in electrical stability studies.

$$\frac{WR^2 \times (\text{RPM})^2 \times 10^{-6}}{1.61 \times 1.34 \times Kw} \times \frac{1}{2}$$
$$= H = \frac{0.231 \times WR^2 \times \text{RPM}^2 \times 10^{-6}}{Kw}$$

Differential equations of governing: As noted previously the three inter-related equations are as follows:

Machine acceleration

$$Tm\frac{dn}{dt} = g + 1.5h - \Delta M \qquad (1)$$

Water acceleration

$$-0.5Tw\frac{dh}{dt} = Tw\frac{dg}{dt} + h \qquad (2)$$

Governor Response

$$-\delta Tr\frac{dg}{dt} = Tr\frac{dn}{dt} + n \qquad (3)$$

Derivation of Machine Acceleration Eq. (1): From equation (1) we have the machine acceleration

$Tm(dn/dt)$ = Net change in per unit torque.

The net change in per unit input torque for small changes is made up of three variables, namely:

g = per unit instantaneous gate

$1.5h$ = per unit instantaneous torque due to per unit instantaneous head

ΔM = per unit torque change due to a step load change

The per unit torque due to the head is assumed equal to the per unit power input which is a function of:

$$1-(1+h)(1+h)^{1/2} \quad \text{or} \quad 1-(1+h)^{3/2}$$

which, for small changes, is approximately equal to $1.5h$.

If load torque is assumed positive, then this component of torque has a negative sign indicating deceleration. Therefore, the full machine acceleration equation in per unit form is

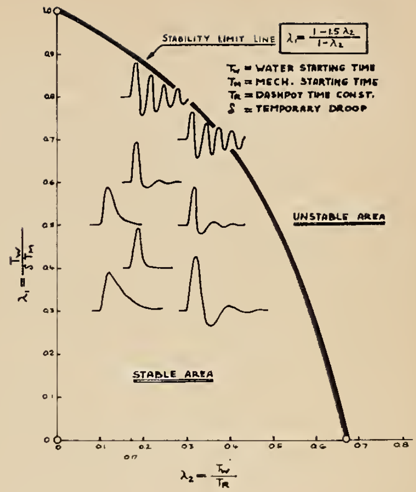


Fig. 2. Curve showing stability criteria for a hydro governor.

$$Tm(dn/dt) = g + 1.5h - \Delta M$$

which is equation No. 1.

NOTE: for load off the sign of ΔM is negative and accelerating torque is

$$g + 1.5h + \Delta M$$

Derivation of Water Acceleration Eq. (2)[2]: The velocity of water in a turbine and intake can be represented by the following relationship:

$$u = K \cdot H^{1/2} \cdot G \qquad \text{(c)}$$

where

H = head
G = Gate position
u = velocity
K a constant

For small variations from a steady state condition, differentiating (c) gives

$$\frac{\Delta u}{u_0} = \frac{1}{2}\frac{\Delta h}{H_0} + \frac{\Delta G}{G} \qquad \text{(d)}$$

where

u_0 = nominal rated velocity
H_0 nominal rated head

Since force equals mass times acceleration, we have the water acceleration due to a change in head expressed by the following equation:

$$\rho LA\frac{d(\Delta u)}{dt} = -A\rho g\Delta h \qquad \text{(e)}$$

where

ρ = mass density of water lb. cu.ft.

A = area of water passages sq.ft.

g = acceleration due to gravity 32.2 ft./sec²

L = total length of water passage in feet

ρLA = mass of water in turbine passages in lb.

$A\rho g\Delta h$ = change in force at turbine runner

Note that there is a negative acceleration for an increase in head. In per unit form equation (e) becomes

$$\frac{Lu_0}{gH_0}\frac{d}{dt}\frac{(\Delta u)}{(u_0)} = -\frac{\Delta h}{H_0}$$

The co-efficient of per unit acceleration may be expressed as a nominal starting time Tw where

$$Tw = LU_0/gH_0 \text{ in seconds.}$$

This constant is usually determined by integrating the various LU_0 sections of the turbine intake + scroll case + draft tube and is usually expressed as $Tw = (\Sigma Lv/gH)$ where L, v, H are rated conditions and $g = 32.2$.

If we let

$$v = \frac{\Delta u}{U_0} \qquad h = \frac{\Delta h}{H_0} \qquad g = \frac{\Delta G}{G}$$

we have
$$Tw\frac{dv}{dt} = -h \qquad \text{(f)}$$

and from equation (d)

$$v = \frac{h}{2} + g \qquad \text{(g)}$$

differentiating equation (g) we have

$$\frac{dv}{dt} = \frac{1}{2}\frac{dh}{dt} + \frac{dg}{dt}$$

and multiplying by Tw

$$Tw\frac{dv}{dt} = \frac{Tw}{2}\frac{dh}{dt} + Tw\frac{dg}{dt} \qquad \text{(h)}$$

Substituting equation (f) in (h)

$$-h = \frac{Tw}{2}\frac{dh}{dt} + Tw\frac{dg}{dt}$$

and rearranging, we have the equation

$$-\frac{Tw}{2}\frac{dh}{dt} = Tw\frac{dg}{dt} + h$$

which is equation No. 2 for water acceleration.

Derivation of Governor Response Eq. (3): Referring to Fig. 1 the dashpot characteristic is such that if a sudden opening G of the gate occurs, point A moves up a distance equal to the gate movement and then settles back at an exponential rate which is a function of the spring constant and the needle valve opening. If we let y equal the distance up of point A at time t, the differential equation of motion of point A is $dy/dt = -K \cdot y$

Where K is a constant. If we put $K = 1/Tr$ the solution of this equation is

$$y = G \cdot e^{-(1/Tr)t}$$

e = Base of natural logarithms

Note that dy/dt equals velocity of dashpot piston at any time t. Tr is known as the relaxation time constant or secondary compensation which is a function only of needle valve opening for a fixed spring.

When $t = Tr$,
we have $Y = Ge^{-1} = 0.368G$

In the governor response equation, we assume a negligible time constant relating pilot valve position to main servo valve. This relationship is very nearly achieved in modern actuator governors for small displacements of the mechanism.

To derive the governor response characteristic, refer to Fig. 1 and assume that the speed is below normal, or a negative per unit instantaneous relative speed $-n$. The gate is opening as a result of the pilot valve being lifted and we have a differential equation of motion involving the velocity of point B as a function of flyball displacement in response to relative speed, and also in relation to the gate velocity as modified by the dashpot piston velocity.

Taking velocities in the gate opening direction as positive, we have the velocity of point B in relation to gate opening velocity equal to

$$\delta(dg/dt) + (n/Tr)$$

Where $\delta(dg/dt)$ equals velocity upward of point B due to gate movement and n/Tr equals velocity downward (this is actually negative as n is negative) due to the dashpot relaxation time Tr, which velocity at any instant is n/Tr (Point B has same time constant Tr as Point A).

Since the gate is opening, the rate of change of relative speed dn/dt is positive and under this influence, point B moves downward at a rate equal to dn/dt and since this is in the negative direction, is $-(dn/dt)$. As point B is common, we have the two velocities equal to one another.

$$\delta\frac{dg}{dt} + \frac{n}{Tr} = -\frac{dn}{dt}$$

or re-arranging

$$-\delta Tr\frac{dg}{dt} = Tr\frac{dn}{dt} + n$$

which is the equation No. 3 for governor response.

Derivation of Differential Equation of Speed vs Time:

Let $p = d/dt$

Original equations now become

$$Tmpn = g + 1.5h - \Delta M \qquad (1)$$

$$-0.5Twph = Twpg + h \qquad (2)$$

$$-\delta Trpg = Trpn + n \qquad (3)$$

From (3)

$$g = -\frac{(Trp + 1)n}{\delta Trp} \qquad (4)$$

From (2)

$$h = \frac{Tw(Trp + 1)n}{\delta Tr(0.5Twp + 1)} \qquad (5)$$

Substitute (4) and (5) into (1), we obtain

$$Tmpn = -\frac{(Trp + 1)n}{\delta Trp} + \frac{1.5Tw(Trp + 1)n}{\delta Tr(0.5Twp + 1)} - \Delta M$$

Above equation is now all in terms of n and t and cross multiplying. Final equation is, substituting $(d/dt) = p$

$$0.5\delta TrTmTw\frac{d^3n}{dT^3} + (\delta TrTm - TwTr)\frac{d^2n}{dt^2} + (Tr - Tw)\frac{dn}{dt} + n = 0 \qquad (6)$$

This third order equation represents a damped or undamped oscillation of n depending on the value of the co-efficients. The Routh-Hurwitz criterion for stability or damped oscillation is as follows:

That

$\delta TrTm - TwTr > 0$ or $Tm - Tw > 0$

$Tr - Tw > 0$

$(Tr - Tw)(\delta TrTm - TwTr) > 0.5\delta TrTmTw$

The latter unequality is the deciding criterion and multiplying out, we have

$$(\delta TrTm + Tw^2) - (TwTr + 1.5\delta TmTw) > 0 \qquad (7)$$

Let $\dfrac{Tw}{\delta Tm} = \lambda_1$ and $\dfrac{Tw}{Tr} = \lambda_2$

Divide (7) by $TwTr$

$$\therefore \left(\frac{1}{\lambda_1} + \lambda_2\right) - \left(1 + \frac{1.5\lambda_2}{\lambda_1}\right) > 0$$

Multiply by λ_1

Now $(1 + \lambda_1\lambda_2) - (\lambda_1 + 1.5\lambda_2) > 0$

The limit of stability is reached for any condition where

$$1 + \lambda_1\lambda_2 = \lambda_1 + 1.5\lambda_2$$

or

$$\lambda_1 = \frac{1 - 1.5\lambda_2}{1 - \lambda_2}$$

We can therefore plot a curve of λ_1 vs λ_2 where all values of these quantities between the curve and the X and Y axis represent varying degrees of stability and all values outside the curve represent unstable conditions.

The following is a table of corresponding values of λ_1 and λ_2 from which a curve may be plotted:

Table II

$\lambda_2 = (Tw/Tr)$	$\lambda_1 = (Tw/\delta Tm)$
0.00	1.0000
.05	.9736
.10	.9444
.15	.9118
.20	.8750
.25	.8333
.30	.7857
.35	.7308
.40	.6667
.45	.5909
.50	.5000
.55	.3889
.60	.2500
.65	.0714
.67	0.0000

Fig. 2 shows a plot of λ_1 and λ_2 together with a series of approximate speed transients for various combinations within the stable area. These were determined from an analog computer study[1].

To solve equation (6) for a given step load change ΔM.

First determine λ_1 and λ_2 for the estimated optimum transient from Fig. 2, and from these values calculate δ and Tr.

Substitute these values in the coefficients of equation (6). The equation now takes the general form

$$\frac{Dd^3n}{dt^3} + \frac{Ed^2n}{dt^3} + F\frac{dn}{dt} + n = 0 \qquad (8)$$

There are three roots of the auxiliary equation, of the general form

$$\alpha, \qquad \beta + j\gamma, \qquad \beta - j\gamma,$$

The general solution of (8) is

$$n = Xe^{\alpha t} + Ye^{(\beta + j\gamma)t} + Ze^{(\beta - j\gamma)t} \qquad (9)$$

Where X, Y, Z are arbitrary constants which can be determined from initial operating conditions and

$$j = \sqrt{-1}$$

Equation (9) can be rewritten as follows:

Where A, B, C are arbitrary constants

$$n = Ae^{\alpha t} + e^{\beta t}(B \sin \cdot \gamma t + C \cos \gamma t) \qquad (10)$$

For the first initial condition we have, when $t = 0$, $n = 0$. Substituting in equation (10) above $0 = A + C$.

For the remaining initial conditions, refer back to equations (1), (2), (3). For $t = 0$ equation (1) becomes for a load off condition.

$$Tm\frac{dn}{dt} = 0 + 0 + \Delta M$$

$$\therefore \quad \frac{dn}{dt} = \frac{\Delta M}{Tm} \qquad (11)$$

Differentiate equation (1) as follows:

$$Tm\frac{d^2n}{dt^2} = \frac{dg}{dt} + 1.5\frac{dh}{dt} \qquad (12)$$

From equation (2) at $t = 0$, we have

$$-0.5Tw\frac{dh}{dt} = Tw\frac{ag}{dt}$$

$$\therefore \quad \frac{dh}{dt} = -2\frac{dg}{dt} \qquad (13)$$

From equation (3) at $t = 0$, we have

$$-\delta Tr\frac{dg}{dt} = Tr\frac{dn}{dt}$$

$$\therefore \quad \frac{dg}{dt} = -\frac{1}{\delta}\frac{dn}{dt} \qquad (14)$$

Now dn/dt at $t = 0$ equals $\Delta M/Tm$

Substitute this relation in (14) and we have

$$\frac{dg}{dt} = -\frac{\Delta M}{\delta Tm} \qquad (15)$$

Substitute (15) into (13) we have

$$\frac{dh}{dt} = +\frac{2\Delta M}{\delta Tm} \qquad (16)$$

Substitute (15) and (16) into (12) we have

$$Tm\frac{d^2n}{dt^2} = -\frac{\Delta M}{\delta Tm} + \frac{3\Delta M}{\delta Tm}$$

$$Tm\frac{d^2n}{dt^2} = +\frac{2\Delta M}{\delta Tm}$$

$$\therefore \text{ At } t = 0 \quad \frac{d^2n}{dt^2} = \frac{2\Delta M}{\delta Tm^2} \qquad (17)$$

Summing up initial conditions at $t = 0$, we have

$$n = 0$$

$$\frac{dn}{dt} = \frac{\Delta M}{Tm}$$

$$\frac{d^2n}{dt^2} = \frac{2\Delta M}{\delta Tm^2}$$

Referring back to equation (9) we have differentiating same

$$\frac{dn}{dt} = \alpha Ae^{\alpha t} + e^{\beta t}(B\gamma \cos \gamma t - C\gamma \sin \gamma t) + \beta e^{\beta t}(B \sin \gamma t + C \cos \gamma t)$$

$$\text{at } t = 0, \qquad \frac{dn}{dt} = \frac{\Delta M}{Tm}$$

$$\therefore \quad \frac{\Delta M}{Tm} = \alpha A + \gamma B + \beta C \qquad (18)$$

$$\frac{d^2n}{dt^2} = \alpha^2 Ae^{\alpha t} + e^{\beta t}(-B\gamma^2 \sin \gamma t - C\gamma^2 \cos \gamma t) + \beta e^{\beta t}(B\gamma \cos \gamma t - C\gamma \sin \gamma t) + \beta e^{\beta t}(B\gamma \cos \gamma t - C\gamma \sin \gamma t) + \beta^2 e^{\beta t}(B \sin \gamma t + C \cos \gamma t)$$

$$\text{At } t = 0, \qquad \frac{d^2n}{dt^2} = \frac{2\Delta M}{\delta Tm^2}$$

$$\therefore \quad \frac{2\Delta M}{\delta T^2} = \alpha^2 A - \gamma^2 C + \gamma\beta B + \gamma\beta B + \beta^2 C \qquad (19)$$

Fig. 3. Multiplying lever for measuring dashpot time constant Tr.

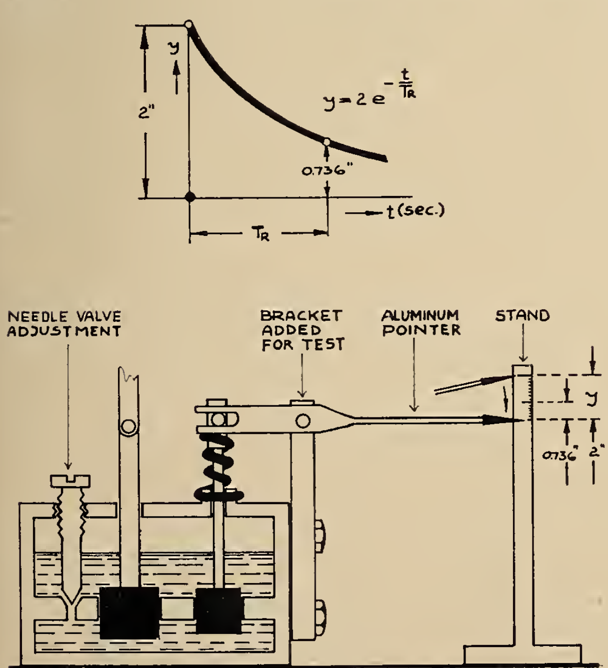
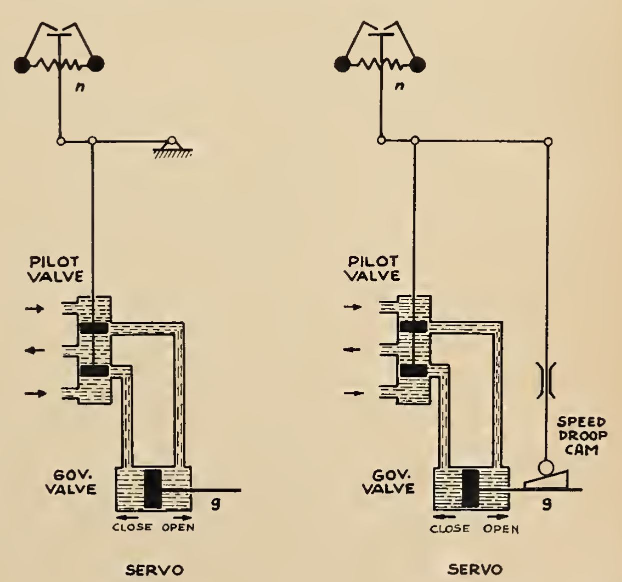


Fig. 4. Typical governor: without speed droop (left), with speed droop (right).



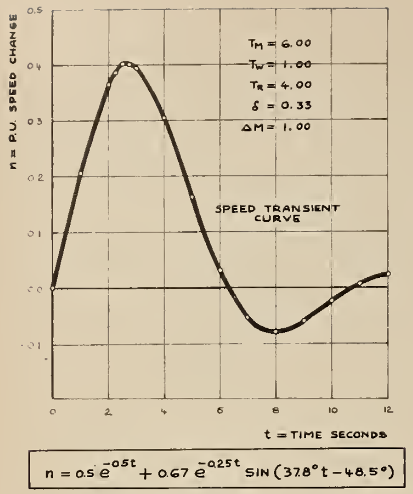


Fig. 5. Typical speed transient characteristic of a hydro governor.

Since at $n = 0$, $t = 0$, we have

$$A = -G$$

$$\frac{\Delta M}{Tm} = (\alpha - \beta)A + \gamma B \qquad (20)$$

$$\frac{2\Delta M}{\delta Tm^2} = (\alpha^2 - \beta^2 + \gamma^2)A + 2\gamma\beta B \qquad (21)$$

From (20) and (21) we can eliminate B and therefore

$$A = \frac{\frac{2\Delta M}{Tm}\left(\frac{1}{\delta Tm} - \beta\right)}{(\alpha - \beta)^2 + \gamma^2}$$

Using this value of A in (19) we can determine B.

Example:

For Winnipeg River we have say $Tm = 6$, $Tw = 1$, $= 0.333$ $Tr = 4$. Substituting these values in original equation gives

$$4\frac{d^3n}{dt^3} + 4\frac{d^2n}{dt^2} + 3\frac{dn}{dt} + n = 0 \qquad (22)$$

Aux. equation is

$$P^3 + P^2 + 0.75P + 0.25 = 0$$

Try first root say -0.5

$$P + 0.5 \overline{\big)\, P^3 + P^2 + 0.75P + 0.25} \; (P^2 + 0.5P + 0.5)$$
$$\underline{P^3 + 0.5P^2}$$
$$0.5P^2 + 0.75P$$
$$\underline{0.5P^2 + 0.25P}$$
$$0.5P + 0.25$$
$$\underline{0.5P + 0.25}$$
$$0$$

Solution of Quadratic

$$p = \frac{-0.5}{2} \pm \frac{\sqrt{0.5^2 - 4 \times 0.5}}{2}$$
$$= -0.25 \pm j0.66$$

Three roots are therefore

$$-0.5 \quad -0.25 + j0.66 \quad -0.25 - j0.66$$
$$\therefore \alpha = -0.5 \quad \beta = -0.25 \quad \gamma = 0.66$$

Solution of equation

$$n = Ae^{-0.5t} + e^{-0.25t}(B \sin 0.66t + C \cos 0.66t)$$

For step function change load off

$\Delta M = -(-1)$, $Tm = 6$, $\delta = 0.333$

$$A = \frac{\frac{2}{6}\left(\frac{1}{0.333 \times 6} + 0.25\right)}{(-0.5 + 0.25)^2 + 0.66^2}$$

$$A = 0.5$$
$$1/6 = (-.5 + .25)\,.5 + .66B \text{ See Eq. 20}$$
$$B = 0.443$$
$$\therefore A = 0.5$$
$$B = 0.443$$
$$C = -0.5$$

$$n = 0.5\,[e^{-0.5t} + 1.33e^{-0.25t}\sin(37.8^0 t - 48.5^0)]$$

This characteristic is plotted on Fig. 5.

Governor Equations in Terms of $\tau = t/Tw$: If we measure t in terms of Tw so that $\tau = t/Tw$ the original equations now become

$$\frac{Tm}{Tw}\frac{dn}{d\tau} = g + 1.5h - \Delta M$$

$$-0.5\frac{dh}{d\tau} = \frac{dg}{d\tau} + h$$

$$-\frac{\delta Tr}{Tw}\frac{dg}{d\tau} = \frac{Tr}{Tw}\frac{dn}{d\tau} + n$$

and the main differential equation of n, using the terms λ_1 and λ_2 now becomes

$$\frac{0.5}{\lambda_1\lambda_2}\frac{d^3n}{d\tau^3} + \left(\frac{1 - \lambda_1}{\lambda_1\lambda_2}\right)\frac{d^2n}{d\tau^2} + \frac{(1 - \lambda_2)}{\lambda_2}\frac{dn}{d\tau} + n = 0 \qquad (23)$$

The initial conditions are now for $\tau = 0$ and for load off

$$n = 0$$
$$\frac{dn}{d\tau} = \frac{Tw}{Tm}\Delta M$$
$$\frac{d^2n}{d\tau^2} = 2\lambda_1\frac{Tw}{Tm}\Delta M$$

It will be noted that for the selected $\lambda_1 = 0.5$ and $\lambda_2 = 0.25$ for Winnipeg River plants, equation (23) has exactly the same co-efficients as equation (22), namely:

$$4\frac{d^3n}{d\tau^3} + 4\frac{d^2n}{d\tau^2} + 3\frac{dn}{d\tau} + n = 0$$

and therefore the roots are the same.

The solution can now be obtained in terms of $Tw/Tm \cdot \Delta M$ and we have for the arbitrary constants

$$A = -C$$
$$\frac{Tw}{Tm}\cdot\Delta M = -0.25A + 0.66B$$
$$\frac{Tw}{Tm}\cdot\Delta M = 0.624A - 0.33B$$

from which $A = \dfrac{3Tw}{Tm}\cdot\Delta M$

$$B = \frac{2.65Tw}{Tm}\cdot\Delta M$$
$$C = -\frac{3Tw}{Tm}\cdot\Delta M$$

The solution of the equation in terms of Tw, Tm, ΔM and the selected λ_1 and λ_2 is

$$n = \frac{3Tw}{Tm}\Delta M\,[e^{-0.25t} + 1.33e^{-0.5t}\sin(37.8^0 t - 48.5^0)]$$

The expression in brackets has a peak value of 0.8, see Fig. 5, therefore, n has a peak value of $2.4(Tw/Tm)\cdot\Delta M$ This latter expression shows that for given values of λ_1 and λ_2 the maximum speed deviation is proportional to Tw/Tm and to ΔM. This simple relationship is very useful in determining the maximum speed deviation for a given step load change when λ_1 and λ_2 are fixed and allows one to quickly estimate the maximum speed change for a given small load change in relation to Tw and Tm.

This relationship[1] is sometimes expressed

$$\frac{\Delta n}{N_0} = K\cdot\frac{Tw}{Tm}\cdot\frac{\Delta p}{P_0}$$

where $K = 2.4$ for selected λ_1 and λ_2

$$\frac{\Delta n}{N_0} = \frac{\text{Change in speed}}{\text{Rated Speed}}$$

$$\frac{\Delta p}{P_0} = \frac{\text{Change in Power}}{\text{Rated Power of Generation on Line}}$$

For example, using Winnipeg River constants, if $Tw = 1$, $Tm = 6$ and $\Delta p/P_0$ say 0.10 p.u.

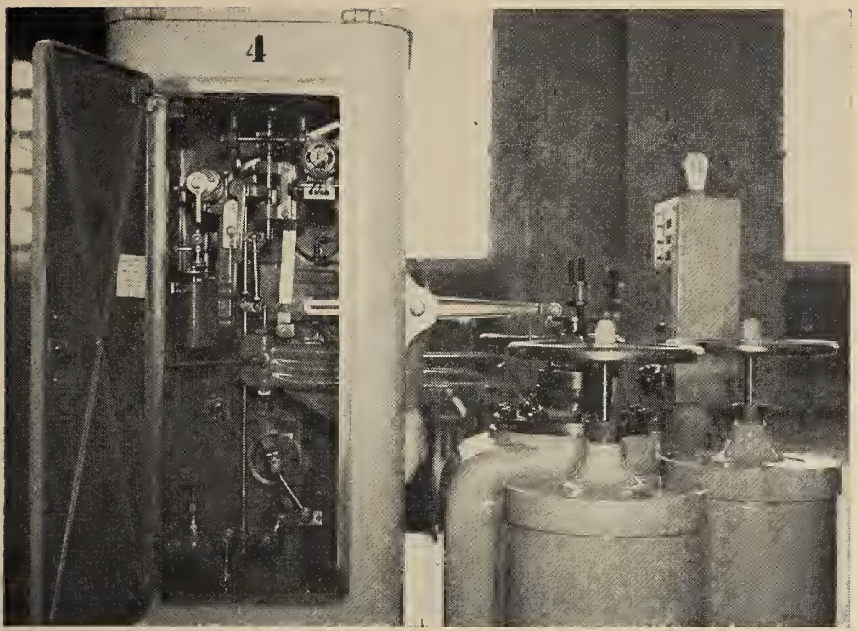


Fig. 6. View of typical actuator governor.

$$\frac{\Delta n}{N_0} = 2.4 \times \frac{1}{6} \times 0.10 = 0.04 \text{ p.u.}$$

speed change or 2.4 cycles for a 10% load change.

Derivation of Simple Governor Equations: Using the same nomenclature and per unit constants as previous and referring to Fig. 4.

Acceleration equation

$$Tm\frac{dn}{dt} = g - \Delta M \qquad (24)$$

When n increases, valve closes and g decreases. However, as n increases g decreases at a time rate depending on a gate closure time say Tg seconds, therefore, the governor equation can be written

$$\frac{dg}{dt} = -\frac{n}{Tg} \qquad (25)$$

Differentiating (24) and substituting (25) we have

$$Tm\frac{d^2n}{dt^2} = -\frac{n}{Tg}$$

This is the familiar simple harmonic motion equation whose general solution is

$$n = A \sin \frac{1}{\sqrt{TmTg}}\, t + B \cos \frac{1}{\sqrt{TmTg}}\, t$$

which shows that the speed is unstable and oscillates up and down at a frequency

$$f\,\frac{1}{2\pi} \cdot \frac{1}{\sqrt{TmTg}}$$

It is obvious that this is an impractical form of governor.

Referring to Fig. 4 it can be observed that the introduction of the cam on the valve rod results in a slower steady state speed as the valve opens.

The equations developed below indicate that this droop produces a stable governor.

Let δ = per unit speed droop of the governor so that for full opening of the valve the steady state speed is permanently down by δ.

The equations now are

Acceleration equation

$$Tm\frac{dn}{dt} = g - \Delta M \qquad (26)$$

Governor equation

$$\frac{dg}{dt} = -\frac{1}{Tg}(n + \delta g) \qquad (27)$$

From (26) $g = Tm\frac{dn}{dt} + \Delta M \qquad (28)$

and $$Tm\frac{d^2n}{dt^2} = \frac{dg}{dt} \qquad (29)$$

Substituting (28) and (29) in (27) we have

$$Tm\frac{d^2n}{dt^2} + \frac{Tm}{Tg}\frac{dn}{dt} + \frac{n}{Tg} = -\frac{\delta \Delta M}{Tg} \qquad (30)$$

The above differential equation (30) represents the well known damped simple harmonic motion, where the damping element is the middle term and is dependent on the speed droop δ. By proportioning the parameters δ, Tm, Tg, various degrees of stability can be achieved as follows:

(1) Highly oscillatory — Low δ, Tm, Tg

(2) Critically damped — $\delta = 2\sqrt{\frac{Tg}{Tm}}$

(3) Over damped — High δ, Tm, Tg

Note that if a signal proportional to acceleration dn/dt can be injected into the governor mechanism in place of speed droop, this will stabilize the machine. This is the principle used in accelerometric governing as used extensively in Europe.

When equation (30) is solved we find that for a load off of 1.0 p.u. the sytem overshoots and then settles down at a steady state speed of $1 + \delta$. The governor mechanism as shown in Fig. 4 is that normally used in steam turbines where Tg can have a relatively low value, and it is therefore possible to operate stably with low values of speed droop in the order of 0.04 to 0.06 per unit. With these low values of droop it is not necessary to provide secondary compensation as is done on a hydro governor.

After a permanent load change for an isolated machine the speed is corrected back to normal by manually adjusting the governor to a different speed droop line.

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AN EXERCISE IN OPERATIONS RESEARCH RCAF AIRCRAFT MAINTENANCE

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Operations Research is a general term that covers many forms of managemen study, but particularly includes mathematical techniques of analysis. The aim of Operations Research has been described by Frank Sawyer of the B.C. Research Council in Western Business and Industry, Aug., 58 as "to maximize the ratio of science to art in the field".

Two major categories of aircraft field maintenance work in the RCAF are the performance of periodic inspections, and the repair of unserviceabilities as they occur in use. The Periodic Inspection which will be classed as a form of unserviceability for the uses of this paper is exactly related to flying hours by definition. The incidence of unserviceabilities caused by component failure or breakdown might also be presumed to be related to flying hours by cause and effect, but a relationship in this has never been fixed for any type of aircraft except in very general terms.

It is the intention in this paper to derive more exact expressions for aircraft group response to use and change, and by relating these expressions to work equations, develop deterministic analyses for the better guidance of maintenance and flying management.

Three assumptions are made (a) Aircraft of the same production identity are subject to a consistent pattern of failure in use, provided their environments, and the techniques of handling applied to them are the same; (b) Handling techniques are subject to a similar pattern of consistency where operators receive the same training, and employ that training to the same ends; (c) The effect of environment upon failure patterns can be isolated and evaluated if the two previous assumptions are correct.

THE DEVELOPMENT OF THE BASIC MATHEMATICAL MODEL

THE FAILURE PATTERN: The overall pattern of failure displayed by an aircraft typical of a group or a fleet of aircraft is a composite of the failure patterns of its various classes or categories of equipment—the engines, the airframe and so on. The failure patterns of individual classes of equipment are separable from each other, but for the broad purpose of this paper the composite pattern will be taken as being as capable of unique identification as the individual pattern may be. Individual patterns may be dealt with as special cases, by extension of the general method.

Symbols and definitions

- N = total number of aircraft on active establishment.
- N_s = number of serviceable aircraft.
- N_u = number of unserviceable aircraft.
- F = flying hours.
- RU = rate at which aircraft become unserviceable (declared).
- RS = rate at which aircraft become serviceable.
- TU = the period of time the average aircraft remains unserviceable during one serviceable plus unserviceable cycle.
- TS = the period of time the average aircraft remains serviceable during one serviceable plus unserviceable cycle.
- TC = the period of time for one serviceable plus unserviceable cycle = $TU + TS$.
- Serv = serviceability = N_s/N
- F/N = flying rate.
- F/N_s = flying intensity.
- SL = Sortie length.

Equilibrium: Only states of equilibrium will be dealt with. At equilibrium the rate at which aircraft become unserviceable is equal to the rate at which they become serviceable, i.e.,

$$RU = RS$$

Rates of becoming Serviceable and Unserviceable, RU and RS: The rate at which aircraft become unserviceable (RU) can be expressed in a number of ways, but whatever form the expression may take it must reflect the following influences:

(a) the effect of periodic inspections (which include modification work);

(b) the attrition effect of flying;

(c) in contrast to (b) above the beneficial effect of increasing sortie length and flying on serviceability;

(d) the attrition effects of ground handling and ground running, which continue whether flying is done or not.

The first agency is simply expressed. Periodic inspections occur exactly in step with flying hours. The expression is:

$$C_1F$$

The second agency is also a function of flying; one can expect the incidence of repair and servicing work to vary first with the type of aircraft, and second with the flying hours. The expression is then of the same form as the expression for inspections, it is:

$$C_2F$$

The third agency is actually a modification of the second. It is a common belief that the ratio of unserviceabilities to flying hours decreases as the intensity of flying (F/N_s) increases. It is certain that Sortie length while perhaps having no effect on the incidence of component breakdown as a function of flying hours, will have an effect on the number of component failures that are involved with each declaration that an aircraft is unserviceable. These two agencies can be expressed conveniently in one factor leading to the tentative expression:

$$C_2F\left[\frac{K - (F/N_s)}{K}\right]\frac{1}{SL}$$

The fourth and last agency is operative only while aircraft are serviceable, its effect will therefore vary directly with the number of serviceable aircraft. The expression is:

$$C_3(N_s)$$

(This may also be taken to include electron "tube" failures which sometime appear more closely tied in with start-up and shut-down than with time-in-use.)

The influences can reasonably be assumed to be independent in their action. The complete expression for RU is then

$$RU = C_1F + C_2F\left[\frac{K - (F/N_s)}{K}\right]\frac{1}{SL} + C_3N_s$$

Division by N_s will simplify

$$\frac{RU}{N_s} = C_1\frac{F}{N_s} + C_2\frac{F}{N_s}\left[\frac{K - (F/N_s)}{K}\right]\frac{1}{SL} + C_3$$

The rate at which aircraft are made serviceable (RS) is the governing rate; and is a measure of the capacity of the Maintenance organization for doing work. The limit of this capacity sets RS and in inevitable sequence the flying rate F/N and RU.

TU and TS

The period of time the average aircraft spends unserviceable (TU) depends upon a number of factors; the nature of the average unserviceability, the organization of manpower, the facilities, the equipment, the quality of supervision, and so on. These factors resolve to a constant, perhaps unique to a given set of circumstances and a certain locale, but still a constant. The variables are manpower MP and RU

$$TU = fcn(MP, RU)$$

TS is a function of aircraft handling and of flying intensity.

$$TS = fcn[(F/N), \text{serv}]$$

Function Relationships at Equilibrium ($RU = RS$): The number of aircraft serviceable (N_s) and therefore available for flying depends on RS, RU, TU and TS. Expressions that link these terms can be derived.

Consider a situation where all aircraft are unserviceable and the function of RS is temporarily suspended

i.e. $N_s = 0 \quad RS = 0$

Consider now that Maintenance work commences at time = 0 and is progressively taken in hand at the rate RS. After a time TU the first aircraft become serviceable, and thereafter aircraft become serviceable at the rate RS. (See Fig. 1.)

Consider also that flying commences with the provision of the first serviceable aircraft. After a time TS (during which aircraft continue to be made serviceable at the rate RS) serviceable aircraft begin to become unserviceable at the rate RU. At this point if $RU = RS$ the fund of aircraft made serviceable (N_s) will remain at this value until the equilibrium state $RU = RS$ is disturbed

$$N_s = RS \cdot TS$$

Similarly $N_u = RU \cdot TU$

At equilibrium $RU = RS$

$$N_s + N_u = RS \cdot TS + RU \cdot TU$$
$$N = RU(TS + TU)$$
$$= RU \cdot TC$$

$$\text{Serviceability} = \frac{N_s}{N} = \frac{RS \cdot TS}{RU \cdot TC} = \frac{TS}{TC}$$

$$TU = \frac{1 - \text{serv}}{\text{serv}} \cdot TS \quad \text{and so on.}$$

WORKLOAD EQUATIONS AND THE OPERATIONS CURVE

The Datum Point

In dealing with manpower, and its output under workload, it is necessary to define some basic and measurable standard of manpower potential, from which calculations can be extended. The point at which this basic measurement of potential will be made will be called the Datum Point, and it is defined as:

That point of reference chosen from field data where the workload and the manpower in use are in balance and where defined standards of efficiency economy and work quality are maintained.

The Field Work Pattern

Fig. 2 shows a typical curve of field operations (Curve 1) in the convenient coordinates of Serviceability and Flying Rate. This field curve pretty exactly reflects demand, and may, but more probably does not maintain equilibrium in its excursions from the Datum Point. The second curve (Curve 2) is developed on the premise of equilibrium at all points, and a linear relationship between output response and Flying Rate; this curve reflects a regular progression in developed potential for sustained equilibrium under varying workload (the arguments for this type of curve will follow in their place) and is shown here for the sake of comparison.

Week by week workload (flying hours) will vary because of weather, change of task, peaks and valleys in operational demand. This variance must be accepted by the working contingent. Technical management must use the manpower potential available to a maximum advantage. This is done by alternating periods of relative strain with periods of relative relaxation coinciding with rising and falling demand. Thus area (B) may be considered as representing a state of relative strain (relative to Datum Point effort), and area (A) is a state of relative relaxation. In passage from area (A) to area (B) or area (B) to area (A) work output (and workload at equilibrium) goes through the Datum Point.

This cyclic phenomenon is particularly marked in operational stations as in Air Division or in Air Defence Command; it is less marked at Training units where the flying task is more constant and predictable, but it is evident to some degree at all RCAF flying units.

Symbols and Definitions

- dp = datum point.
- I = time a/c remains u/s for average inspection.
- S = time a/c remains u/s for average failure.
- a/c = aircraft.
- AE = aero-engine.
- AF = air-frame.
- I_w = the time the average a/c is actually under work during I.
- S_w = the time the average a/c is under work during S.

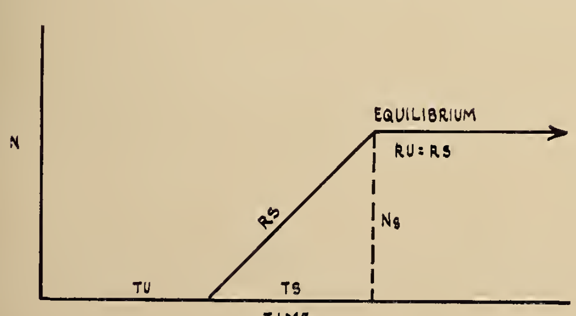


Fig. 1. Function relationship.

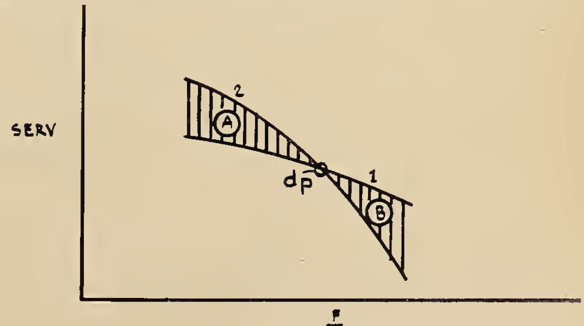


Fig. 2. Theoretical and field work patterns. Curve 1 is the field work curve.

M_i = the number of tradesmen fully employed during the average inspection.
M_s = the number of tradesmen fully employed during the average snag rectification.
γ = $I_w M_i$ — the man days required to perform the average inspection.
β = $S_w M_s$ — the man days required to perform the average rectification of failure.
M_{serv} = the number of tradesmen necessarily allotted full time to Servicing duties.
TMP = total manpower, Maintenance plus Servicing.
MP = manpower general.
MPa = manpower available for repair and inspection work.
MPr = total manpower required for repair and inspection work.
Q = Queue.
K, C = constants.
Subscript i = inspection.
Subscript s = snags.
Subscript w = work.

$$a = C_1 \frac{F}{N}$$

$$b = C_2 \frac{F}{N}\left[\frac{K - (F/N_s)}{K}\right]\frac{1}{SL} + C_3 \text{ serv}$$

$$A + B = (a + b)\frac{1}{\text{serv}}$$

Aircraft Trades and Manpower Calculations

There are seven trades involved in the maintenance and servicing of RCAF aircraft. In calculations to follow only the personnel in the trades of AE and AF are considered. The reason for this is that the other trades Electrical, Instrument, and so forth, can be considered auxiliary, not in importance of course, but in functions and numbers. The trades of AE and AF contain the major proportion of tradesmen; the work of AE and AF is easier to observe and record than of auxiliary trades because they participate from the beginning to the end of any inspection, and they are at least equally if not more involved in repair work. From these circumstances, and by the fact that the numbers of auxiliary tradesmen bear a constant proportionate relationship to the number in the primary trades of AE and AF for any given aircraft and given task, the complication of directly calculating their work can be avoided, as when the number of AE and AF tradesmen are determined for a given circumstance, the total number of tradesmen required can be obtained by the proportionate addition of auxiliaries. Throughout this paper manpower calculations will be of AE and AF only; the all-trades manpower values being neglected for the sake of simplicity.

Manpower Required (MPr): The equation for Manpower Required per aircraft is obtained by multiplying the elements of inspections unserviceability rate, and the breakdown rate in the equation for RU/N by the respective values of mandays required to recover these unserviceabilities, i.e.:

$$a\gamma + b\beta = \frac{MPr}{N}$$

or in terms of F/N_s

$$A\gamma + B\beta = \frac{MPr}{N_s}$$

Manpower Available and Total Manpower: Total manpower (TMP) is considered as being made up of two elements: Manpower available for Maintenance work (MPa) and Manpower necessarily allotted to Servicing tasks (M_{serv})

$$TMP = MPa + M_{serv}$$

or $$\frac{TMP}{N} = \frac{MPa}{N} + \frac{M_{serv}}{N}$$

The personnel represented by M_{serv} are assumed to be limited in their work to purely Servicing tasks; as refuelling, marshalling, the performance of Daily Inspections, starting up and so on, all functions which have no bearing on Serviceability as such, M_{serv} under the restriction of the definition term "necessarily allotted" will vary with the flying load, and the number of serviceable aircraft, and may be adequately described by the equation:

$$M_{serv} = K_1 N_s + K_2 F$$

or $$\frac{M_{serv}}{N} = K_1 \text{ serv} + K_2(F/N)$$

Because M_{serv}/N is a variable term, the manpower available for Maintenance (MPa/N) will be variable within a fixed complement of manpower TMP/N

$$\frac{MPa}{N} = \frac{TMP}{N} - \frac{M_{serv}}{N}$$

Other MP Relationships: Other relationships of time, task, manpower and unserviceabilities rates are needed for analysis, and may be constructed with the elements of I, S, M_i, M_s and the rate equations for RU/N or RU/N_s.

The rate at which manpower changes tasks per day per aircraft is

$$aM_i + bM_s = \frac{MP \text{ change (or turnover)}}{N} \quad \text{(per day)}$$

The total number of unserviceable aircraft at any time is

$$aI + bS = \frac{N_u}{N} = 1 - \text{serv}$$

The total number of unserviceable aircraft upon which manpower is employed at any time is

$$\frac{(Nu)_w}{N} = aI_w + bS_w$$

The queue of unserviceable aircraft awaiting manpower at any time is

$$\frac{Q}{N} = aI + bS - (aI_w + bS_w)$$
$$= 1 - \text{serv} - (aI_w + bS_w)$$

Other relationships will suggest themselves.

The Standard Operations Curve

An Operations Curve is constructed by extension from a given Datum Point and expresses at every point in its length equilibrium between the rates of becoming unserviceable and recovery ($RU = RS$). The extensions might follow any number of paths, and a Standard Operations Curve against which actual extensions may be compared requires definition.

The Standard Operations Curve will be based on the queue of unserviceable aircraft awaiting manpower

$$\frac{Q}{N} = 1 - \text{serv} - (aI_w + bS_w)$$

The circumstances of a fixed complement of men and a fixed task (F is constant) but a variable number of aircraft in use (N is variable) will occasionally require analysis and for these circumstances the change of queue with changing numbers of aircraft is simply expressed: queue will vary exactly with N, i.e.

$$\frac{Q}{N} \alpha \frac{N}{F}$$

or

$$1 - \text{serv} - (aI_w + bS_w) = K\frac{N}{F}$$

where the constant of proportionality is fixed by the circumstances of the Datum Point.

For a fixed complement of men, a fixed number of aircraft but a variable task (F is variable) which is the more common case, and therefore the more potentially fruitful field for analysis, queue cannot be described so directly or exactly. Queue in this case would seem to be more closely related to manpower and manpower potential than any other element. On this line of reasoning queue will be accepted as varying inversely as the difference between MPa/N and MPr/N, and the Operations Curve that develops from this premise will be taken as the Standard Operations Curve for variable F and constant N for a fixed complement of men, i.e.

$$\frac{Q}{N} = \frac{K}{(MPa/N) - (MPr/N)}$$

or

$$1 - \text{serv} - (aI_w + bS_w)$$

$$= \frac{K}{(MPa/N) - (MPr/N)}$$

where the constant of proportionality and values of I_w and S_w are fixed by the circumstances of the Datum Point. As will be demonstrated, I_w and S_w are necessarily constant for a best utilization of MPa. Typical curves are shown in Fig. 3.

ANALYSIS OF THE TRANSIENT STATE

The Transient State ($RU \neq RS$): Up to this point analysis methods have been developed within the restriction of equilibrium ($RU = RS$). In dealing with the transient state ($RU \neq RS$) a new line of development must be followed. The transient state is probably more common than a state of equilibrium, if we include the small and random fluctuations that invariably, and hour by hour, surround a point or state of equilibrium. But unless these fluctuations become extremely large which would be a rare circumstance, they can be ignored. The significant transient state is the sustained one, usually planned and which can occur or develop in a number of ways. One possible exercise in transients is shown in the two diagrams in Fig. 4.

In the diagrams—point (A) represents point of departure and point of return and is in fact, the Datum Point for the exercise. The transition from (A) to (B) marks a major change in workload, accomplished in what might be thought of as zero time. The line BC marks a true transient state, in this case $RS > RU$. In passage from B to C flying potential (serv) is increased until intersection with the Operations Curve at C restores equilibrium. The transition from C to D is again a major change of workload accomplished in hypothetical zero time; point D being a point of choice. The line DA marks a transient state as did line BC but in this case $RU > RS$. In passage from D to A flying potential decreases until finally intersection with the Operations Curve at A again restores equilibrium. The decline in potential from D to A can proceed by a number of paths, as by constant F/N or constant F/N_s or any desired variation of these rates.

Transient State Calculation: In the transient state $RU \neq RS$ and the recovery rate (RS) may be greater or less than the becoming unserviceable rate (RU) depending on the workload and manpower available.

The rate of change of serviceable aircraft in respect to time must be equal to the difference between RU and RS, i.e.

$$\frac{d(N_s)}{dt} = RS - RU$$

or in terms of (N_s/N) = serviceability

$$\frac{d(N_s/N)}{dt} = \frac{d(\text{serv})}{dt} = \frac{RS}{N} - \frac{RU}{N}.$$

There is an expression for RU/N in terms of F/N and serv. RS/N can be expressed in terms of F/N and serv.

The substitution of these expressions for RS/N and RU/N leads to a differential equation in serv and time (assuming F/N constant or expressible in terms of serv), or substituting for

$$F/N = F/N_s \cdot \text{serv}$$

(assuming F/N_s constant or expressible in terms of serv).

Transient state developments for an exercise based on the pattern of the one shown in Fig. 4 are calculated in Appendix A using typical field data.

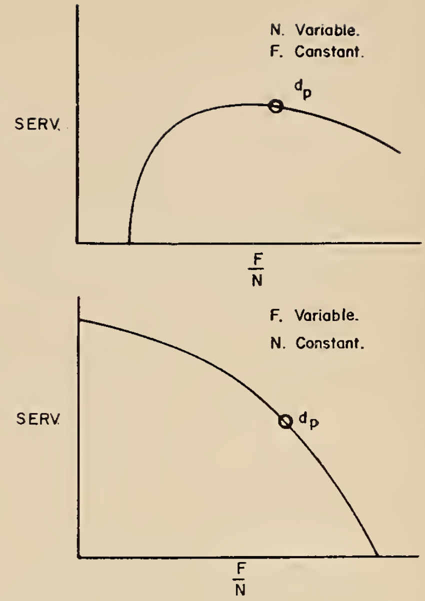


Fig. 3. Typical standard operations curves.

PRACTICAL TESTS OF THE ANALYTIC APPROACH

Collection and Processing of Data

Analytic methods, however useful they may promise in concept, can never be better than the data used in them. So with the development of an analytic method there must be a parallel development of means for collecting data of the desired accuracy, and the simple pro forma directions for data processing.

Samples of the reporting form and the process sheet that have evolved during the course of some 8 months of trial are shown in Appendix C(1) and (2) They cannot be claimed as being the last word, but they achieve three prime requirements:

(a) they provide internal checks for consistency and relative accuracy;

(b) they facilitate a maximum accuracy consistent with the limitations of skill and time that are a part of field personnel and circumstances;

(c) they have been reduced to the barest bones of simplicity, and still provide the essential statistics.

The pro forma for data processing is self-explanatory. A little background however is necessary to evaluate the data reporting form.

There are seven essential elements of aircraft performance data; items B to G of the report form and statistics of loss of effective aircraft through non-availability of components to be replaced—"Awaiting Spares", and "Awaiting Flight Test" shown on the report form.

There are five essential additional elements of data for manpower analysis; these are items H to K of the report, and constants for the M_{serv} equation on the report form. Manpower data for repair and inspection work are based on observation of men employed, and the tasks upon which they are employed, at a defined schedule of times during each working day. The system and the observation schedule can best be described by a diagram. (Fig. 5.) The hatched areas represent MP employed, the vertical dimensions of the hatched areas represent the number of aircraft being worked on.

Manpower data for M_{serv} equations are obtained by continued observation, which is expected by repeated corrections or confirmations of initial estimates to establish accurate values for the constants.

Behind the daily data reporting a secondary system of accuracy checks is employed. The reports themselves provide means of checking relative accuracy; the secondary system is designed to check absolute accuracy and is based on the basic aircraft log books which by routine maintenance procedures are entered for many purposes including the recording of all unserviceabilities. For various reasons these log books do not lend themselves to day by day reference; however they are a good source of history, and should fundamentally be the most accurate if not the most convenient source of unserviceability data. The data supplied by the report forms (recorded independently of log books) are therefore compared for absolute accuracy with data drawn from log books for selected periods in past time.

The log books also provide statistics of total major breakdowns as distinct from total number of declared unserviceabilities. The rates of breakdown and the rates of declaring unserviceable (grounding the aircraft) are found clearly separable except for Harvard aircraft, and the separation can in some degree at least be related with the Sortie Length for the type of aircraft involved.

Field Data Checks

Some data results from Harvard and T33 aircraft are shown in Fig. 7 and 8.

From these and other results it may be deduced that for the basic relationship of RU/N_s against F/N_s

(a) the relationship is essentially linear for the F/N_s values investigated and therefore, for practical purposes the correction factor

$$\left(\frac{K - (F/N_s)}{K}\right)$$

may be neglected for the F/N_s range in use.

(b) The data deviation for collection increments below 500–600 flying hours is in the range of ± 30 per cent, but as the flying hour increments increase, the data deviations diminish so that for flying increments of 1500 flying hours or more innate deviation is not distinguishable from reporting or recording error, which is estimated as ± 5 per cent.

(c) The factor for SL cannot be said to be tested. Sortie Length is relatively constant for any given type of aircraft for Training Command uses. The effect of its variation can be guessed but it could not be confirmed. Therefore for the further uses of this paper the term $1/SL$ will be dropped from the RU equations.

ANALYTIC USES

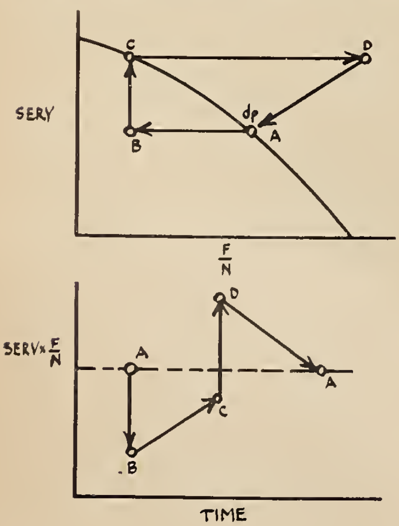
Categories of Investigation

There are two general categories of analysis:

(a) The situation analysis;

(b) extrapolation from the known state to the unknown state through the development of Curves of Performance Indices and Operations Curves.

Fig. 4. A development based on transients.



Performance Indices: The end products of RCAF flying stations activities are many and varied, but the prime one is useful flying hours. Utilization of RCAF aircraft is fixed by definition as so many hours per month per aircraft. This definition sets the basic task goal in terms of F/N. The efficiency with which the task is performed, the economy of resources, the reserve of potential and so on, constitute a fruitful field for analytic investigation and which is best approached through the use of what will be called Performance Indices; a number of useful members of the PI family are:

(a) serviceability

(b) $\text{serv}\,\dfrac{F}{N}$

(c) $\text{serv}\,\dfrac{F}{N}\cdot TS$

(d) $\text{serv}\,\dfrac{F}{N}\left(\dfrac{MPa - MPr}{N}\right)$

(e) $\dfrac{F}{RU}$

(f) $\dfrac{MPr}{F}$

(g) $\dfrac{MPa}{F}$

(h) $\dfrac{MPa - MPr}{N}$

Situation Analysis: A prime use of the situation analysis would be to provide guides to better management of resources in hand, and better utilization of manpower and equipment already in use. The situation analysis is readily directed at the calculation of optimums.

The best way to indicate its use is to give an example.

The daily turn-over of manpower on task has a direct relationship with the number of aircraft held unserviceable under work. The higher the rate of manpower turn-over (and therefore work turn-over) the smaller will be the number of aircraft under task.

The number of aircraft held unserviceable under task is directly related to time on the job, the equation here is

$$\frac{(N_u)_w}{N} = aI_w + bS_w$$

The values of I_w and S_w are fixed by the terms M_i and M_s the average crew sizes for inspection and repair work respectively. The higher these values the lower will be the value of I_w and S_w (γ and β are constant) with a corresponding reduction in $(N_u)_w$.

The values of M_i and M_s fix the rate of manpower turnover per day per aircraft per task for a given flying rate and serviceability

$$MP/N(\text{turnover}) = aM_i + bM_s$$

Then to have a least value of

$$[(N_u)_w]/N$$

M_i and M_s must be at maximum values, but there are two circumstances that make large values of M_i and M_s difficult, the first is the bottleneck effect, by which the number of men that can actually be employed in a task is limited by the accessibility of the task; the second is the organizational difficulty of handling a large crew turnover.

The requirements then are conflicting; both MP/N (turnover) and $[(N_u)_w]/N$ should approach minimum values. An optimum relationship can be derived assuming equal weight for both requirements

$$\frac{(N_u)_w}{N} = aI_w + bS_w \rightarrow \text{a min.}$$

$$\frac{MP\ (\text{turnover})}{N} = aM_i + bM_s \rightarrow \text{a min.}$$

If both equations are to approach a minimum their product must approach a minimum.

$$a^2 I_w M_i + b^2 S_w M_s + ab(S_w M_i + I_w M_s) \rightarrow \text{a min.}$$

but $a^2\gamma + b^2\beta$ and ab are constant in value at a given flying rate and serviceability, therefore

$$S_w M_i + I_w M_s \rightarrow \text{a min.}$$

or

$$S_w M_s \left(\frac{M_i}{M_s} + \frac{I_w}{S_w}\right) = \beta\left(\frac{M_i}{M_s} + \frac{I_w}{S_w}\right) \rightarrow \text{a min.}$$

As β is constant, and as

$$I_w M_i = \gamma \quad \text{and} \quad S_w M_s = \beta,$$

a minimum occurs when

$$\frac{M_i}{M_s} = \frac{I_w}{S_w} = \sqrt{\frac{\gamma}{\beta}}$$

The relationship may be used by comparing actual manpower disposition with it, confirming the disposition as acceptable or establishing the need for adjustment.

PI and Operations Curves

Two examples of uses of PI and Operations Curves will be given.

The first is the calculation of build-up and decay of potential as fixed by defined rates and intensities of flying, and a given Operations Curve. The example will also demonstrate the use of transient equations. The first example is based on Fig. 6.

The exercise is limited to a discussion of potential decay from Point (D) to point (E) given that flying intensity (F/N_s) can be maintained at a constant value from (D) to (E) and that in this passage all unserviceabilities are covered as they occur to the limit of MPa, and inspection work is only undertaken as men can be spared from repair work. The M_i and M_s values remain constant throughout the exercise.

The exercise is based on the following data:

(a) The Datum Point values (at point A) are:

$F/N = 2.0 \qquad \gamma = 40$

$\text{serv} = 0.50 \qquad \beta = 2.0$

$$\left(\frac{MPa}{N}\right)_{dp} = 1.30 \text{ (remains constant)}$$

(b) The RU/N equation is:

$$\frac{RU}{N} = \left(0.01\frac{F}{N}\right) + \left(0.10\frac{F}{N} + 0.10\,\text{serv}\right) = a + b$$

(c) Potential is to be spent by constant $F/N_s = 8.0$, continuing until $F/N = 4.0$ at (E).

(d) The Serviceability at the beginning of the exercise is 0.90.

The questions to be answered are:

(a) How long does it take for the serv to decline from 0.90 at point (D) to 0.50 at point (E)?

(b) How many hours are flown?

The calculations are given in Appendix A and the answers are given in Table I compared for interest with the results if a flying rate of $F/N = 4.0$ had been sustained from (D) to (E) instead of flying intensity of $F/N_s = 8.0$.

Table I
Comparative Answers for the First Example given under PI and Operations Curves

	Time for Potential to Subside from (D) to (E)	Total Flying Hours at (E)
at constant $\frac{F}{N_s} = 8.0$	6.70 days	$33.7N$
at constant $\frac{F}{N} = 4.0$	12.9 days	$51.6N$

In the second example an aircraft establishment of 100 will be reduced to 75 with a reduction in workload but without reduction of a flying task set at 200 hours per day.

The example proceeds in two stages:

(a) an improvement in Serviceability by better manpower disposition between inspections and repair crews based on obtaining a closer approach to the disposition $\frac{M_i}{M_s} = \sqrt{\frac{\gamma}{\beta}}$

(b) an increased flying intensity.

The calculations are extensive and are contained in Appendix D.

The data upon which the calculations are based are as follows:

(a) the original state:

$F/N = 2.0$ (datum point values)

$\text{serv} = 0.60$

$MPa = 3.0 - 0.40(F/N) - 0.20\text{serv}$ (datum point values)

$MPr = 0.44(F/N) + 0.10\text{serv}$ (datum point values)

$I = 7.0$

$S = 0.65 \qquad \gamma = 30$

$I_w = 6.0 \qquad \beta = 1.0$

$S_w = 0.40$

$RU/N = 0.01(F/N) + 0.140(F/N) + 0.10\text{serv}$

(b) in the next step an Operations Curve is generated with improved values of I_w and S_w

$I_w = 3.5 \qquad I = 4.0$

$S_w = 0.40 \qquad S = 0.62$

(The new value of I is based on the change in I_w, S is adjusted to round serv off to 0.70.)

(c) in the last step an Operations Curve is generated on the basis of the data of sub para (b) but the Datum Point is now based on increasing F/N_s from approximately 3.0 to $F/N_s = 5.0$ and the Datum Point moves to $F/N = 2.65$ and serv $= 0.53$.

The original and final states are compared in Table II.

Conclusions

The assumptions of the Thesis appear to be correct, within certain statistical limits and population levels. These limitations rule out discussion of small numbers of aircraft with small accumulations of flying hours. There is still a prospect of useful analysis if large accumulations of flying hours can be gathered for a small population, but the results must be used with caution, as the average aircraft of the small population may not be a true average of the aircraft as a class because a complete stratum of individual variations may not appear.

Data collection for analysis does not require expert attention, once familiarity with the methods and terms is gained.

The analytic method then may be said to have a prospect of day by day use and application. Nothing more can be claimed in advance of test in practice.

Acknowledgement

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Table II
Tabulated Answers to the Second Example given under PI and Operations Curves

	Task	N	Serv	MPr	F/RU	F/N_s
Original	200 Hrs/day	100	0.60	94 mandays/day	5.5	3.3
Final	200 Hrs/day	75	0.53	91 mandays/day	5.8	5.0

Appendix A
Calculations of the Transient State

Step (1). Calculate the difference between the energy available, and manpower required for snag work between D and E. Given—Manpower available per aircraft is

$$\frac{MPa}{N} = 1.30 \text{ mandays/day/aircraft} \qquad \text{at } \frac{F}{N_s} = 8.0$$

$$\left(\frac{MPr}{N}\right)_{\text{snags}} = \left(0.10\frac{F}{N} + 0.10\,\text{serv}\right)\beta$$

$$= \left(0.10\frac{F}{N_s} + 0.10\right)\beta\cdot\text{serv}$$

$$= 1.80\,\text{serv}$$

Then

$$\frac{MPa}{N} - \left(\frac{MPr}{N}\right)_{\text{snags}} = 1.30 - 1.80\,\text{serv}$$

Step (2). Form the Transient Equations.

There are two stages of work applications

Case (a) from serv $= 0.90$ to serv $= 0.72$, i.e. when $1.30 - 1.80\,\text{serv} = 0$ ....(serv $= 0.72$) during which only snags are dealt with

Case (b) from serv $= 0.72$ to serv $= 0.50$ during which more energy is available than is needed for snags and this excess can be applied to inspection work.

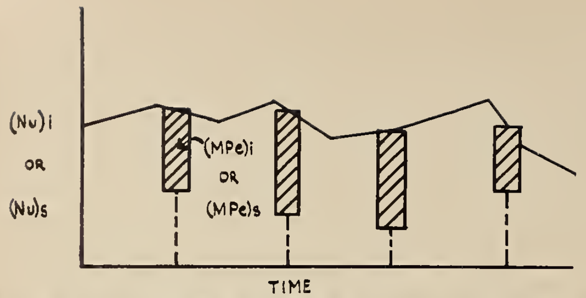


Fig. 5. Manpower observation—method and schedule. The hatched areas represent MP employed, the vertical dimensions of the hatched areas represent the number of aircraft being worked on (Nxi or Nxs of the process sheet Appendix B). Random observations are made within scheduled periods of 30 minutes each.

Case (a)

$$\frac{d(\text{serv})}{dt} = \frac{RS}{N} - \frac{RU}{N}$$

$$= \frac{1.30 - 1.80\,\text{serv}}{\beta} - 0.01\frac{F}{N_s}\cdot\text{serv}$$

$$= \frac{1.30 - 1.96\,\text{serv}}{2}$$

$$dt = \frac{2}{1.96}\,\frac{d(\text{serv})}{(0.66 - \text{serv})} = -1.02\,\frac{d(\text{serv})}{\text{serv} - 0.66}$$

$$t = -1.02\log(\text{serv} - 0.66) + C$$

evaluating C from $t = 0$ at serv $= 0.90$

$$t = 1.02\left[\log\frac{0.24}{\text{serv} - 0.66}\right]$$

Case (b)

$$\frac{d(\text{serv})}{dt} = \frac{1.30 - 1.80\,\text{serv}}{\gamma} - 0.01\frac{F}{N_s}\cdot\text{serv}$$

$$= \frac{0.26 - \text{serv}}{8}$$

$$t = -8\log(\text{serv} - 0.26) + C$$

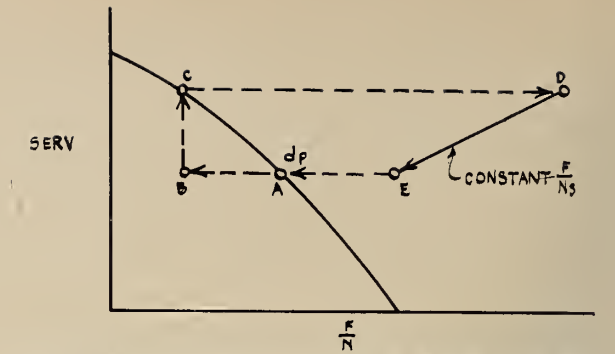


Fig. 6. The transient exercise involving calculation of decay of potential from Point D to Point E described in the text and in Appendix C.

evaluating C from $t = 0$ (for case (b)) at serv $= 0.72$

$$t = 8\log\left[\frac{0.46}{\text{serv} - 0.26}\right]$$

Step (3). Calculate time required

Case (a)	serv = 0.90 to serv = 0.72	$t = 1.42$
Case (b)	serv = 0.72 to serv = 0.50	$t = 5.28$

Total Time = 6.70 days

Step (4). Calculate the Total Flying Hours (TFH)

$$TFH = \left(\frac{F}{N}\right)N\cdot t = \left(\frac{F}{N_s}\right)N\cdot\text{serv}\cdot t$$

$$= 8N\cdot\text{serv}\cdot t = 8N\int\text{serv}\cdot dt$$

Case (a)

$$dt = -1.02\,\frac{d(\text{serv})}{\text{serv} - 0.66}$$

$$TFH = -8.16N\int\frac{\text{serv}\cdot d(\text{serv})}{\text{serv} - 0.66}$$

$$= -8.16N[\text{serv} + 0.66\log(\text{serv} - 0.66)] + C$$

Fig. 7. Three months' data collection (June—July—August 1959) of Total Unserviceabilities from the Log Books of two separate fleets of Harvard aircraft. Each fleet contains 50 a/c.

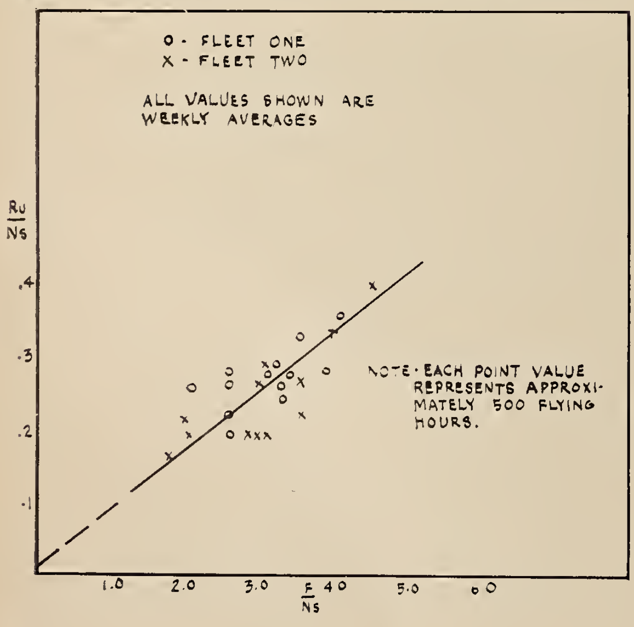
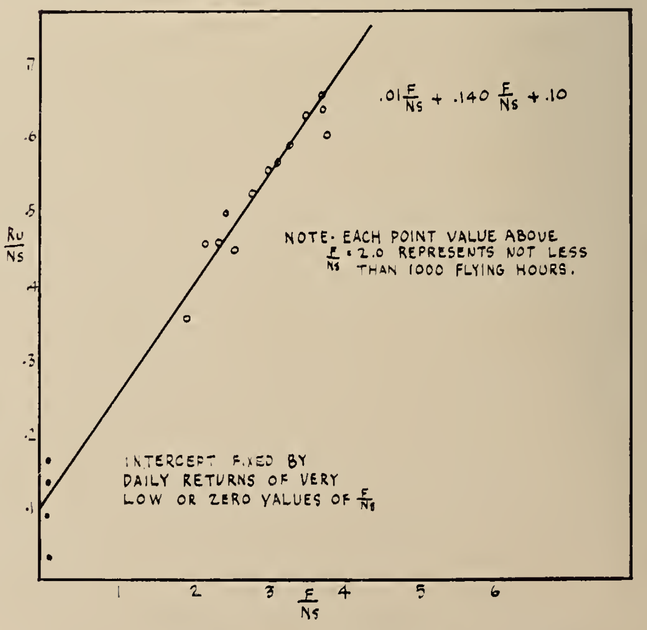


Fig. 8. Data collection from daily records averaged on a semi-monthly basis of incidence of Declared Unserviceabilities for 80 T33 aircraft May to December 1959.



evaluating TFH from serv $= 0.90$ to serv $= 0.72$ gives

$$TFH \text{ for case (a)} = 8.8N$$

Case (b)

$$dt = -\frac{8d(\text{serv})}{\text{serv} - 0.26}$$

$$TFH = -64N[\text{serv} + 0.26 \log(\text{serv} - 0.26)] + C$$

evaluating TFH from serv $= 0.72$ to serv $= 0.50$ gives a

$$TFH = 24.9N \text{ for case (b)}$$

Total TFH serv $= 0.90$ to serv $= 0.50$

$$= (8.8 + 24.9)N = 33.7N$$

Appendix B

Calculations for Problem on Aircraft Establishments

Step (1). Calculate the equation for the original Operations Curve, calculate F/RU, MPr/MPa, and MPr.

The standard Operations Curve equation is

$$1 - \text{serv} - (aI_w + bS_w) = \frac{K}{(MPa/N) - (MPr/N)}$$

$$1 - \text{serv} - \left(0.06\frac{F}{N} + 0.056\frac{F}{N} + 0.04 \text{ serv}\right)$$

$$= \frac{K}{3.0 - 0.40(F/N) - 0.20 \text{ serv} - 0.44(F/N) - 0.10 \text{ serv}}$$

$$1 - 1.04 \text{ serv} - 0.116\frac{F}{N} = \frac{K}{3.0 - 0.84(F/N) - 0.30 \text{ serv}}$$

K is calculated from the dp values $F/N = 2.0$ serv $= 0.60$ and the original Operations Curve equation is

$$2.83 - 1.19\frac{F}{N} - 3.42 \text{ serv} + 0.097\left(\frac{F}{N}\right)^2$$

$$+ 0.91 \text{ serv} \cdot \frac{F}{N} + 0.31 (\text{serv})^2 = 0$$

The equation for $$\frac{MPr}{MPa} = \frac{0.44(F/N) + 0.10 \text{ serv}}{3.0 - 0.40(F/N) - 0.20 \text{ serv}}$$

$$\frac{MPr}{MPa} \text{ at the } dp = 0.452$$

$$\frac{MPr}{N} \text{ at the } dp = 0.94N$$

MPr with $N = 100 = 94$ mandays/day

Now calculate the equation for F/RU

$$\frac{RU}{N} = 0.15\frac{F}{N} + 0.10 \text{ serv}$$

$$1.0 = 0.15\frac{F}{RU} + 0.10\frac{N_s}{RU}$$

$$\frac{F}{RU} = \frac{1 - 0.10(N_s/RU)}{0.15} = 6.6 - 0.66\frac{N_s}{RU}$$

APPENDIX C. (1.)

MAINTENANCE STATISTICS CALCULATION SHEET

	STATION———————	
No	PERIOD———————	
NE ft	RU/N = a + b	
No–NE ft	a = .01 F/N b = ___ F/N + ___ Serv	
N		
Ns	Nus = ______	Nui = ______
F	Nxs = ______	Nxi = ______
F/N	MPes = ______	MPei = ______
F/Ns	RU_s = ______	RSi = ______
Ns/N	Serv	
RUs		
RU	RUs + RSi	
RU/Ns		
RU/N	RU/Ns × Ns/N	
TC	N/RU	
TS	Ns/RU	
TU	TC − TS	
S	Nus/RUs	
Sw	Nxs/RUs	
I	Nui/RSi	
Iw	Nxi/RSi	
Ms	MPes/Nxs	
Mi	MPei/Nxi	
β	Sw × Ms	
γ	Iw × Mi	
MP_R/N	$a\gamma + b\beta$	

$$= 6.6 - \frac{0.66}{0.15(F/N_s) + 0.10}$$

$$\frac{F}{RU} = 6.6 - \frac{4.4}{(F/N)\cdot(1/\text{serv}) + 0.66}$$

F/RU at dp for the original state is

$$6.6 - \frac{4.4}{4.0} = 5.5$$

Step (2). Calculate the equations for the Operations Curve with an improved value of $I_w (I_w/S_w$ and M_i/M_s more closely approaching $\sqrt{\gamma/\beta})$. This time

$I_w = 3.5$, $I = 4$ $S = 0.62$

$$1 - \text{serv} - \left(0.035\frac{F}{N} + 0.056\frac{F}{N} + 0.04 \text{ serv}\right)$$

$$= \frac{K}{3.0 - 0.84(F/N) - 0.30 \text{ serv}}$$

evaluating K at $F/N = 2.0$ serv $= 0.70$ gives the general equation

$$2.91 - 1.11\frac{F}{N} - 3.42 \text{ serv} + 0.89 \text{ serv} \cdot \frac{F}{N}$$

$$+ 0.076\left(\frac{F}{N}\right)^2 + 0.31(\text{serv})^2 = 0$$

MAINTENANCE STATISTICAL REPORT STN__________________

Date: from____________________ to____________________ A/C TYPE__________________

A	B	C	D	E	F	G	H	I	J	K	L	M	N
							Nx		MPe				
Date	RU Snags	RS Insp.	Nu Insp.	N	Ns	F	Snags	Insp.	Snags	Insp.			
Total													
Av.													

Average daily value, in work days, of delay elements that are not affected by the application of Manpower:

- Awaiting Spares_____
- Awaiting Flight Test__________ (NE_{ft})
- Other__________

TMP__________________

$$\frac{\text{M Serv}}{\text{N}} = \text{K}_1 \text{ Serv} + \text{K}_2 \frac{\text{F}}{\text{N}}$$

K_1__________________

K_2__________________

Signature__________________________

APPENDIX C. (2.)

The equation for MPr/MPa is the same as in Step (1), then

$$\frac{MPr}{MPa} = 0.46 \qquad \left(\frac{MPr}{N}\right)_{dp} = 0.95N$$

$$MPr \text{ at } N = 100 = 95 \text{ mandays/day}$$

The equation for F/RU is the same, then

$$\frac{F}{RU} = 5.4$$

Step (3). Calculate the Operations Curve equation for the final step. This development is based on the same data as for Step (2) except that N is reduced to 75, $F/N_s = 5.0$.

$$F \text{ is still } 200 \qquad \frac{F}{N} = 2.65 \qquad \text{serv} = 0.53$$

$\frac{MPa}{N}$ takes on a new value

$$\frac{MPa}{N} = 4.0 - 0.40\frac{F}{N} - 0.20 \text{ serv} \qquad (N \text{ now } = 75)$$

then

$$1 - 1.04 \text{ serv} - 0.091\frac{F}{N} = \frac{K}{4.0 - 0.84(F/N) - 0.30 \text{ serv}}$$

evaluating K at the dp values of $F/N = 2.65$ serv $= 0.53$

$$3.75 - 1.21\frac{F}{N} - 4.55 \text{ serv} + 0.076\left(\frac{F}{N}\right)^2$$

$$+ 0.91 \text{ serv} \cdot \frac{F}{N} + 0.31(\text{serv})^2 = 0$$

$$\frac{MPr}{MPa} = \frac{0.44(F/N) + 0.10 \text{ serv}}{4.0 - 0.40(F/N) - 0.20 \text{ serv}}$$

$$\left(\frac{MPr}{MPa}\right)_{dp} = 0.432$$

$$\frac{MPr}{N} = 1.21$$

$$MPr \text{ at } N = 75 = 91 \text{ mandays/day}$$

The equation for F/RU is the same as before, then

$$\frac{F}{RU}(\text{at} dp) = 5.81$$

SOIL PROBLEMS IN MINING ON THE PRECAMBRIAN SHIELD

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Soils encountered in mining operations on the Precambrian Shield are almost all glacial in origin, ranging all the way from well-drained sand and gravel deposits, such as eskers and some moraines, to the silts and clays deposited in glacial lakes. All too many experiences in Canadian mines have shown that the latter cannot safely be regarded as "just mud" to be moved or built upon as the case may be. The character of typical glacial clays is described, and the reason for their unusual properties—an artificially high natural moisture content—is explained. Against this background examples are given of satisfactory experience in handling such material (as at Steep Rock) and in founding mining structures upon them (as in the Malartic field), with some constructive reference to troubles that have been experienced elsewhere with soils of this type.

WHEN subsurface exploration work is carried out at a mining property, the soil mantle covering the bedrock is generally considered to be mainly a nuisance, delaying the drilling program and increasing its cost. The driller usually lists the soil mantle simply as "overburden" or "soil" without attempting any detailed description. Although soil is regarded by exploration drillers, and even by some mining engineers, as an impediment to their work, it can be the over-riding factor in determining the economic feasibility of a mining property. Two of the most serious failures of mining enterprises on the Shield were due to soil and not to rock problems. The purpose of this paper is to demonstrate that a general knowledge of the properties of soils can be of fundamental importance to any mining development program and that soil conditions at a mining property can be assessed as a part of the exploration program for the orebody at small additional cost.

Soils of the Shield

The present physiography of the Precambrian Shield has been largely determined by the Wisconsin glaciation. The entire Shield was covered by a continental ice sheet which removed almost all previously existing superficial deposits and many of the softer rocks of the Shield. The drainage pattern previously existing was disturbed leaving a new and very young drainage system. The Shield also inherited a sporadic mantle of unsorted glacial till usually granular in character. On higher ground, gravel deposits such as kames, eskers, and terraces are numerous. Deposits such as these have assisted greatly in the construction of transportation routes in otherwise difficult terrain.

Some parts of the Shield have been subjected to inundation by glacial lakes, and by the sea along the Gulf of the St. Lawrence and along the Arctic coast. In such areas, lacustrine and marine deposits occur which are usually more troublesome than the glacial and glacial-fluvial soils. Most of these soils are comparatively recent in origin and have been subjected to very little erosion due to the generally poor drainage conditions. Because of the poor drainage, peat deposits have accumulated on the surface of much of the Shield; these are now widely known as the Canadian phenomenon of "muskeg".

The water-laid fine-grained soils of the Shield can conveniently be grouped into three classes: lacustrine sands and silts, fresh water varved clays and silts, and post-glacial marine clays. The last-named group occurs only in the St. Lawrence lowlands below elevation 700 and along Hudson Bay, James Bay and the Arctic coast below elevation 800 ft.[1] The varved clays and silts have a much wider distribution, being confined to former glacial lake basins. They are characterized by a laminar structure consisting, usually, of alternating layers of silt or silty clay and clay. Lacustrine silts and sands are also widely distributed in the vicinity of the old glacial lakes, being frequently associated with the varved clays.

It is the varved clays that are so frequently encountered in mining operations on the Shield. When disturbed they liquefy very easily and so constitute the "mud" that is so often an impediment to Canadian mining development. Unless carefully examined, the varved structure of these soils may not be recognized but it is usually present even though it does not affect directly the instability of the soils when they are disturbed. Many mining engineers will have seen small slides in this type of soil but its basic instability is most pointedly illustrated by the experiences at the Beattie and the Josephine Mines. These will be summarized but only with constructive intent, so that the failures involved may form a background for a better appreciation of the character of some of the soils met with on the Shield, which it is the purpose of this paper to illustrate.

The Josephine Mine: October 1946

The Josephine Mine[2] was started in 1941 to win iron ore that had been found in a vertically inclined body of haematite under Parks Lake in the Algoma District of Northern Ontario. To control underground water, it was decided to dewater Parks Lake and to provide a permanent surface pumping installation to take care of local drainage. The sediments in the bottom of Parks Lake, consisting of 5 or 6 ft. of organic ooze on the surface underlain by 6 or 7 ft. of fine bluish silt, and the remaining depth, varved clay, were left undisturbed after the dewatering operation. A vertical shaft was then sunk at a site adjacent to the lake to a depth of 1225 ft. Seven levels were established at 265 ft., 415 ft., 515 ft., 715 ft., 815 ft., 1015 ft., and 1190 ft. respectively below the shaft collar. Fig. 1 shows a vertical section of the mine.

Mining started in November 1945, ore being won by the open stope method, working from the lower levels up. It continued until 13 October 1946 by which time 173,000 tons of haematite had been extracted. By the end of June, the 6-36 stope had caved up to 30 ft. above the fifth level. Caving continued during July and August and the stope seemed to increase above the fifth level. On 14 September, men working on the fourth level heard considerable caving in the east end of the mine and examination showed that the 36 stope was caving rapidly. By the end of September the cave had opened the stope to a height of 35 ft. above the fourth level. Movements continued and it was soon impossible to follow the progress of the caving in detail. A simple calculation, based on the known expansion of broken ore relative to ore in place, showed that caving could not continue beyond the third level. Despite this a slight depression in the lake bottom was observed on 9 October.

This depression had the general outline of the 36 stope and was located directly over it. As no increase in water was noted underground, operations were allowed to proceed. A small quantity of muck was pulled from the 36 stope to check for a further depression. Between 9 and 13 October, 220 tons of ore were drawn from the stope. As a result, in the early morning of 13 October, a further subsidence was noted.

At 9.30 a.m., the shift boss found black gelatinous ooze in the east end of the fifth level. It was coming through the broken ore in the workings. Immediately salvage work was started on a round-the-clock basis. From 13 to 15 October salvage work continued and a small flow of the ooze continued. At 2.30 p.m., 15 October, men on the fifth level heard a noise similar to escaping air. The cause of the noise was black ooze pouring down the ore pass. Immediately all men were taken out of the mine.

Very shortly, a decided movement was noted in the lake bed. First the original depression settled with the cracks increasing in size. Later, slabs of mud with grass began to move into a central vortex. The flow continued, gradually increasing in volume and speed. About 5 p.m. an old pump barge 30 ft. x 16 ft. x 6 ft. began moving toward the hole. When about 25 ft. from the vortex, it dammed the flow momentarily and a hole appeared in the lake bed. The mud cascaded over the edge of the hole and disappeared. The barge moved until it reached the hole, tipped, and dived in end first. It wedged momentarily, and as the hole increased in size, disappeared. It could be seen that the walls of the hole were a grey, claycy material. At this point the hole continued to enlarge rapidly. Air was gulped down and later regurgitated explosively throwing muck about 200 ft. in the air. By 5.30 p.m., the hole was 60 ft. in diameter. Gradually, the movements slowed until at 6 p.m. all movement had ceased.

On the following day, a survey showed that the resulting depression covered about 3½ acres, had a mean depth of 14 ft. and 80,000 cu. yd. had disappeared into the mine. The mud had risen in the shaft to within 30 ft. of the fifth level. It was estimated that voids underground were about 85,000 cu. yd. To prevent any further movement, the mine was filled with water. It is believed that most of the material which entered the mine was from the surface layers of organic ooze and fine silt.

The published account of this failure raises a number of questions regarding the cause of the cave-in. Although no comment can be made on the behaviour of the orebody in caving, it is almost certain that the principal lake bottom sediments which filled the mine were typical glacial and post glacial soils of the type that liquefy so quickly following disturbances such as that caused by the caving that extended up to the lake bottom.

Beattie Mine: July 1943

The Beattie Mine was located at Duparquet in Northwestern Quebec, about 22 miles from Rouyn. Mining was started in 1931, the gold-bearing ore being won by a combination of "glory-hole" and underground stoping methods. The "glory-hole" was worked during the summer months and the ore was extracted underground during the winter. The "glory-hole" was gradually enlarged each season; by about 1937 it was 1,000 ft. long with an average 100 ft. width. The west end of the pit was entirely in rock while the eastern end was covered by overburden. The overburden was made up of varved clay overlying water-laid sand. The stripping of the overburden was accomplished with a tower dragline and grew progressively deeper with each season. In 1937 a small landslide occurred at the eastern end of the pit, but it did not seriously interfere with mining operations. Several other small landslides occurred from 1937 to 1942. About the middle of June 1943, a tremendous earth flow, involving several million cubic yards of varved clay, occurred which completely filled the "glory-hole" and all the underground workings. So fluid was the clay that it ran along an underground drift over half a mile towards the neighbouring Donchester Mine which had an underground connection with the Beattie Mine.[3]

While production continued at the Donchester Mine, steps were taken to rehabilitate the Beattie property. Surface stripping operations were continued as weather permitted to remove the clay from the pit. Underground the workings were cleared by sluicing with high pressure water jets and pumping the resulting slurry to the surface. In June 1946, shortly after the surface stripping activities began for the season, another large earth flow occurred, again completely filling the "glory-hole" and the underground workings. Fig. 2 is a panoramic view of the lake which now occupies the crater formed by the two large earth flows. The rock wall of the "glory-hole" appears on the right of the photograph.

Both these unfortunate developments at important mines have one feature in common — the sudden liquefaction of soil which had appeared to be reasonably solid material. This property of soils is well recognized in modern studies of soils and is generally designated as high sensitivity.

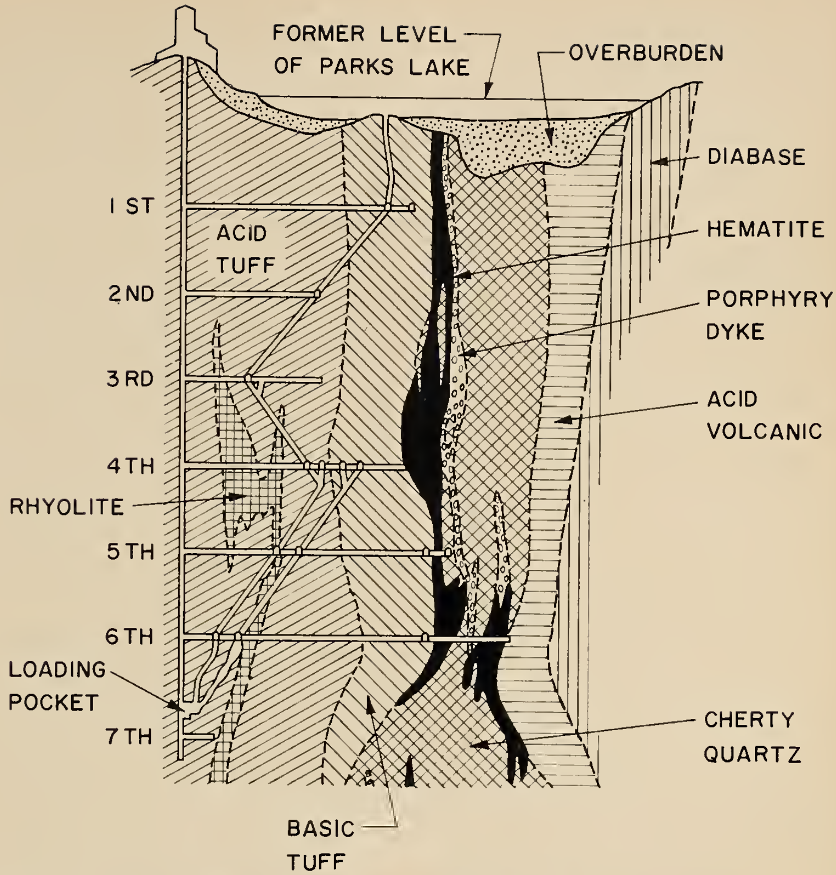


Fig. 1 Shaft section of Josephine Mine (after Gallie, 1947)

Modern Soil Studies

The scientific study of soils, called *soil mechanics,* is now a well recognized part of the practice of civil engineering. Although only about a quarter of a century old as an organized discipline, soil studies have been carried out throughout the whole history of modern civil engineering but only by individuals working alone until about 1925. Today, technical journals and excellent text books bring together in convenient form modern knowledge of the character and behavior of soils as used by the engineer. A selection of recommended texts is listed at the end of this paper.

The accurate determination of soil types is a first step in the proper engineering study of soils. This can be approached by investigating first the distribution of different size soil particles which make up the soil mixture. Fig. 3 is an illustration of the way in which the mechanical analyses of soils can be graphically represented. Cumulative curves have been plotted for a silty glacial till, a uniform sand, a lacustrine silt, and a marine clay. Mechanical analyses of soils are carried out first by sieving, and then by a sedimentation process for particles smaller than No. 200 sieve.

As soil studies have progressed, the significance of mechanical analyses as a means of distinguishing soils has decreased because the properties of importance in the engineering use of soils are not always related directly to mechanical composition. "Indicator tests" have therefore been developed to illustrate the reaction of the soil particles with varying quantities of water because, as can well be imagined, it is the variations in the three-phase air-water-soil mixture that is significant in determining the behaviour of soils. The indicator tests normally conducted are the determination of the natural water content and the "Atterberg limits".

Atterberg limits are given by two tests designed to indicate the plasticity characteristics of cohesive soils. Such soils can exist in three states: liquid, plastic or solid. The liquid limit, as determined by the Atterberg method, is the water content at the change from the plastic to the liquid state as determined by an admittedly arbitrary but simple and satisfactory test procedure. The plastic limit is the corresponding water content defining the change from the plastic to the solid state and is determined by an even simpler test. The difference between the two water contents is defined as the plasticity index. The interrelation of the indicator test results and their use in distinguishing soil types is well shown by the simple but very useful diagram reproduced as Fig. 4.

Procedures for all of these tests have been set out in ASTM Standards;[4] the test can be done at small cost and with a minimum of equipment. Beyond the indicator tests, there are now laboratory tests that determine the mechanical strength of soils either in their natural or in a disturbed state. The most important mechanical property is the shear strength of the soil. This can be determined, with a reasonable degree of accuracy for cohesive soils, by means of unconfined compression tests conducted upon cylindrical soil samples carefully preserved so as to be as close as possible to their original condition and moisture content when tested.

Of special importance for the fine-grained soils encountered on the Shield is the relation between the natural water content of a soil and its Atterberg limits. This relation can be expressed in a number of ways. One of the most common methods is to use the "liquidity index". This is expressed as:

$$LI = \frac{Wn - PL}{LL - PL}$$

where LI = liquidity index
Wn = natural moisture content
LL = liquid limit
PL = plastic limit.

If the liquidity index of the soil is greater than unity, the soil will have a natural water content higher than its liquid limit so that it would be expected to be in the liquid state. Much of the fine-grained soil found on the Shield has a liquidity index considerably greater than one and yet it is to all appearances in a perfectly stable plastic condition. The appearance is deceptive, however, since the soil is inherently unstable, the excess of water being held in what may be called an internal microscopic honeycomb structure, formed by minute soil particles during the course of sedimentation. It follows that, if such soils are disturbed from this natural but inherently unstable condition, the soils will lose their natural character and liquefy in a very short period of time, with results that can be disastrous.

This high liquidity index does not require a laboratory for its detection since it can be readly detected merely by taking a sample of the undisturbed soil and moulding it between the fingers. The excess moisture will soon make itself evident by the dramatic change in consistency between the undisturbed and remoulded clays. This is a simple field test that should therefore be familiar to every mining engineer engaged in work on the Shield. If he encounters soils with a high liquidity index he should immediately take steps to have proper soil studies made so that danger may be avoided and the natural characteristics of the soil used to good advantage.

Buildings at Malartic

As an illustration of what a careful but relatively simple soil study can do, there may be mentioned the design and construction of buildings for the Malartic Goldfields mine at Halet, Quebec. Those who know the clay belt of northern Ontario and Quebec will be familiar with the numerous foundation problems that have developed with buildings constructed directly upon the clay of this area, particularly if loads have been heavy. With such examples as a guide, the consulting engineer to Malartic Goldfields Ltd. (E. H. Bronson) consulted the senior author while he was on the staff of the University of Toronto and so was able to undertake such special soil studies. An investigation was made of the soil conditions at the site of new mine buildings that were planned. Eighteen simple auger borings showed that rock level was generally about 35 ft. below the surface so that it could be used for the support of extra heavy loads. The overlying soil had a high liquidity index but at the same time had a reasonable shear strength if not disturbed. Most of the foundations for the necessary buildings were therefore designed as spread footings using a safe bearing capacity for the soil as determined by shear tests; the heavier loads were carried to rock by means of 235 end-bearing piles. No real problems were encountered during construction and the buildings have continued to serve satisfactorily, in contrast to other buildings not very far away from the site, constructed upon exactly the same type of clay but without the benefit of preliminary soil studies.

Experiences at Steep Rock Lake

As a further example of what can be done by the application of soil studies to mining development, there may be mentioned the experience gained with the development of the great iron mine of Steep Rock Iron Mines Ltd. In 1943 and 1944 Steep Rock Lake, with an area of about 10 square miles was drained by pumping, following completion of a major river diversion project. The bed of the lake consisted of varved clays to depths up to about 150 ft. with liquidity indices up to 1.5. The instability of this vast deposit of soil is well shown in Fig. 5 showing the "stream" of soil which flowed down a relatively flat slope after being shaken out of a dragline bucket in which it had been excavated in the form of a tough, sticky but coherent mass. All the soil surrounding the areas that had to be cleared for open-pit working was characterized by corresponding potential instability.

The mine management supported fully the idea of careful soil studies.[5] These demonstrated that, if undisturbed, the soil could be trimmed to slopes that would be stable and safe. Extensive test boring, soil sampling, and soil testing showed that, despite the wide extent of the soil deposits to be dealt with, there was a reasonable degree of uniformity to soil properties that permitted over-all slope designs to be prepared. Basically the method used was to trim the excavated soil to a slope of 1 in 3, limiting the vertical height of each slope to 20 ft. A horizontal berm, the width depending on the shear strength of the soil, was then excavated, and graded gently away from the slope so that drainage would not reach the erodible face of the slope but would be collected in ditches at the back of each berm and led away under constant control. The most striking example of this general design was the Hogarth Barrier, a natural dam 160 ft. high consisting entirely of the unstable soil already described, trimmed as indicated, stretching across the Middle Arm of the lake. It served to isolate the area of the so-called "A" orebody which was then excavated in open pit to a depth of over 500 ft. below the original lake level, and 200 ft. below the top crest level of the barrier which was, originally, the level of the bottom of the lake.

It must be stressed that the figures given for the slopes used at Steep Rock are of relevance only for soils with the exact characteristics of those encountered in the bed of Steep Rock Lake. These were based on a large number of relatively simple shear tests on undisturbed soil samples. The Steep Rock experience, however, illustrates what can be done, even in a lake-bed filled with unstable soil, by the application of the scientific approach to soil, coupled with a full

Fig. 2 View of crater left by earth flows at Beattie Mine

appreciation on the part of management of the vital importance of even the simplest precautions in maintaining unstable soil in its natural state, and in controlling all ground and surface water in the vicinity.

Soil Studies in Exploration Work

In the exploration stage of mining development, geophysical surveys may be conducted, air photographs obtained and studied, and a test drilling program initiated. All these approaches are also commonly used in soil exploration work. In mining development, therefore, it is possible to combine preliminary soil studies, where soil is present in any significant quantity, with normal mining exploration at little, if any, extra cost and with the expenditure of very little extra time, provided only that soil exploration is recognized as an essential part of the preliminary program.

All the geophysical methods normally used in the search for ore, with the natural exception of the use of the Geiger counter, can be used to indicate depths to bedrock and significant changes in the character of overburden. Seismic methods are particularly applicable to determinations of depths to bedrock so that in areas such as that in the vicinity of the Beattie Mine it would be possible to determine well in advance of mining operations whether there is a rock barrier between any body of open water such as Duparquet Lake and the area to be developed for mining purposes. Aerial photo interpretation is now an established technique with an appreciable literature of its own (some reference to which is made in the accompanying bibliography). In many cases it is possible to distinguish major soil variations from a study of aerial photographs and identify land forms that may reveal soil conditions.

A test drilling program is naturally the most positive way of determining soil conditions. If overburden is present over an orebody, the exploratory holes necessary for ore exploration must be cased down to rock. Durng the sinking of holes to rock level, soil samples that provide definite information on soil properties can readily be obtained, with very little delay, by forcing split-barrel or Shelby soil samplers into the undisturbed soil. These samples can then be subjected to the simple indicator tests already mentioned and can give a good general picture of subsurface soil conditions. These could be supplemented later by more detailed studies if necessary. Observations of water levels in completed drill holes can often give invaluable information about groundwater conditions. It must be emphasized that only by means of actual undisturbed soil samples can subsurface conditions be determined with accuracy, sediment in wash water being never completely reliable and sometimes quite definitely misleading.

In the case of granular soils, a careful record of the necessary force to drive in the samplers can indicate the density and strength of the soil being penetrated. The bearing capacity can be determined, at least in a preliminary way, from the number of blows required to drive a standard split-barrel sampler 1 foot, given the weight of hammer used and its drop. Even in the case of cohesive soils, the driving record will give at least an indication of the variability of the soil formation and a general idea of its strength characteristics. Soil samples, obtained as indicated, must be used for accurate determination of bearing capacity and other necessary strength characteristics for all cohesive (fine-grained) soils.

Some Soil Problems in Mining

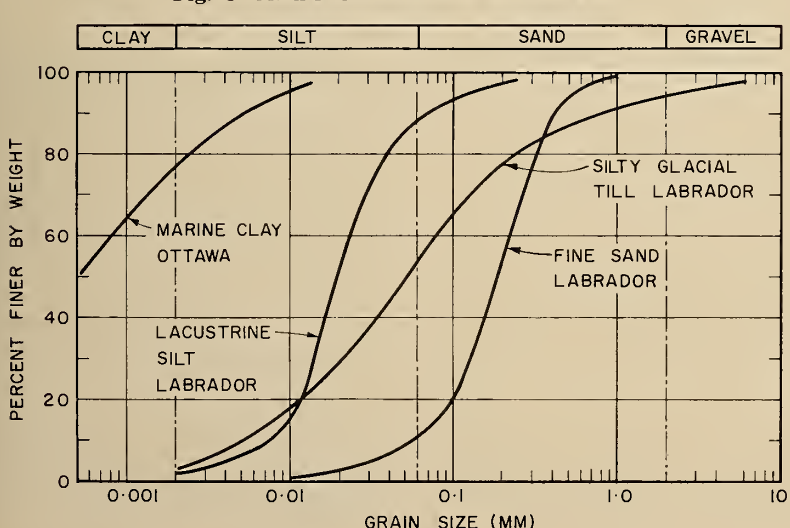
Some of the major soil problems that may be encountered in mining operations on the Precambrian Shield may be briefly noted in conclusion to illustrate how the application of soil mechanics studies may assist in the successful development of a mining property. Table I presents this information in summary form in relation to the main types of soil that may be encountered.

Roads: The first construction work at a mining prospect is usually the building of access to the property, either road or rail. Road construction will almost always be the first requirement, but soil studies are similar for both road and rail construction. In each case it is desirable to achieve an all-weather road requiring a minimum of maintenance. Frost action and soft ground crossings are the main problems in road construction. Aerial photographs can be of great assistance in locating the route to avoid muskeg areas and to take advantage of the best soil conditions. If soft ground deposits cannot be avoided, aerial photographs and the muskeg classification system developed by Radforth[6] can assist in minimizing the problem. The height of fills should be kept to a minimum. If it is necessary to construct fills more than 5 or 6 feet high, an investigation should be conducted by auger borings. The severe winter climate of the Shield, coupled with poor drainage conditions, makes frost action a major road problem. The only positive method of overcoming this problem is by the selection and use of non-frost susceptible materials for road building.

Deep excavations: In sinking shafts or stripping overburden from open pits, deep excavation in soils may be necessary. In granular soils excavation work can proceed only if success is first achieved in controlling groundwater. Slopes will be stable when cut to the angle of repose of the material. For deep shafts, groundwater can be controlled by several methods including dewatering by well points, freezing, grouting, stabilization by electroosmosis, or chemical grouting. The choice of method will depend largely on the exact soil conditions.

For fine-grained soils, in addition to the control of water in any pervious strata encountered, the shear strength of the soil must be consid-

Fig. 3 Grain-size distribution of four soils



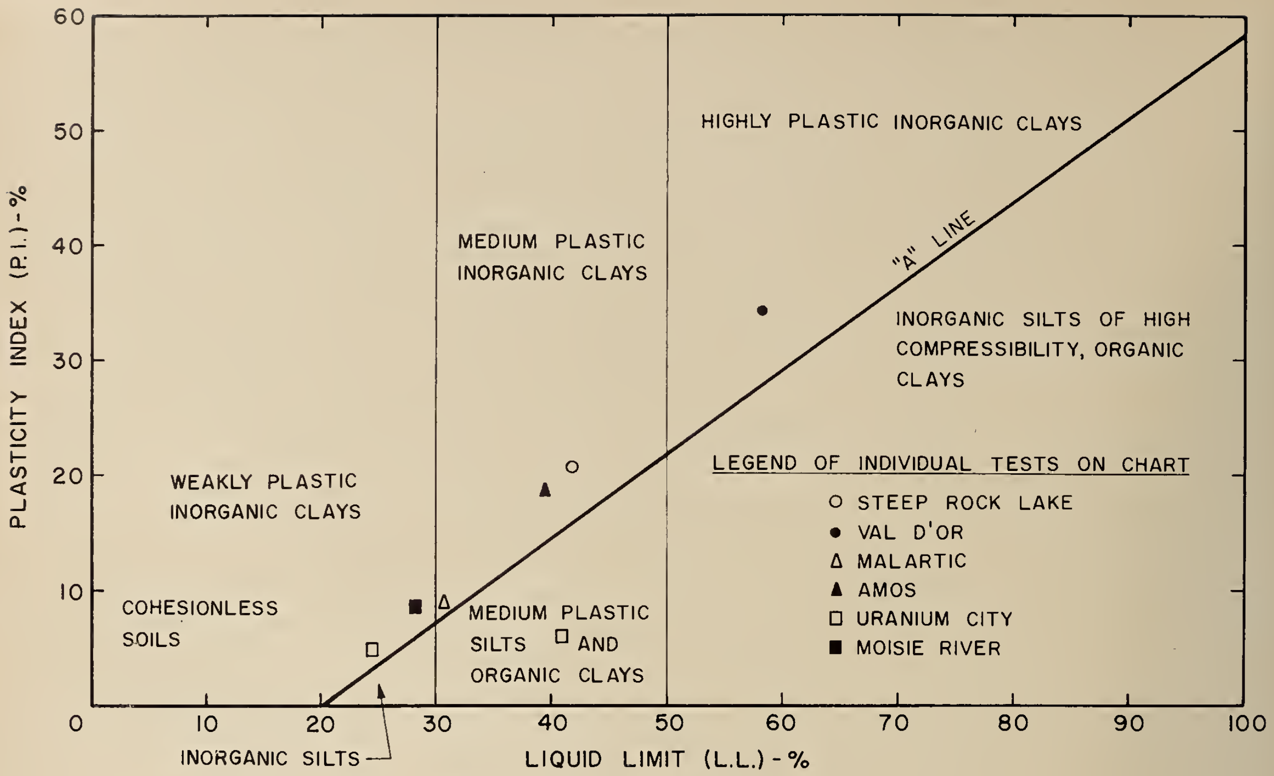


Fig. 4 Casagrande's plasticity chart

ered. It can be shown that a shaft in cohesive soil, even though adequately shored, should not proceed beyond a depth defined by $Dc = Nc \cdot (S_s/\gamma)$, where Dc is the critical depth, Nc is the coefficient depending on the dimensions of the shaft (9 for deep shafts), γ is the density of the clay, and S_s is the undrained shear strength.[7] If an open excavation proceeds beyond this point, the bottom will probably blow in. Special construction methods will then be necessary to complete the shaft to the desired depth. Side slopes and the shear strength of the soil will limit the depth to which open excavations for pits can be carried. In all cases of deep excavation in soils, a test boring and soil testing program conducted by a competent authority can lead to safe design and construction methods. When the soils involved are sensitive, it is imperative that the risk of failure be kept to a minimum. This can be done by the careful application of soil mechanics.

Foundations for buildings and surface installations: As the experience at Malartic Goldfields Mine has shown, it is quite possible to found buildings directly even on sensitive soil. With adequate soil information available, safe designs can be determined from the shear strength and compressibility characteristics of the soil. If the soil conditions are difficult, pile foundations, to transfer loads to bedrock, may be the only satisfactory solution. In keeping with the over-all and always dominant requirement that soil should be disturbed as little as possible from its natural state, piles should only be used when preliminary soil studies have shown them to be absolutely necessary. At Malartic, they were useful in conveying the heaviest loads directly to bedrock so that the necessary disturbance of the varved clay by driving was immaterial. Pile driving in such clays usually tends to liquefy them to a certain extent so that, in extreme cases, it is possible actually to reduce the bearing capacity of a building site (on sensitive clays) rather than to increase it by the driving of piles. The use of piles should never be considered without first obtaining expert advice on the necessary foundation design.

Stockpiles: It is sometimes necessary to build up large stockpiles of ore or other material on a mining property. The loads so placed on the underlying ground can be considerable; there have been many instances of failure of underlying ground. If this merely disturbs the ground under the pile the consequences may be serious enough, but soil failure will always affect a considerable area around a pile so that adjacent structures may be moved or even destroyed. Soil studies are therefore an essential preliminary to the start of any stockpiling on any surface other than solid rock.

Tailing dams: Correspondingly, in ore processing operations, it is sometimes necessary to store the tailings from mill operations. If this cannot

Fig. 5 Excavated silt flowing after being dumped from dragline bucket

TABLE I

Soil Problems in Relation to Mining

Soil Type and Condition	*Type of Problem*			
	Road Construction	Shaft Sinking	Deep Open Excavations	Building Foundations
Well drained gravels and sands		Adequate shoring	Side slopes = angle of repose	Possibility of settlement under vibratory loads
Saturated gravels and sands	Drainage will control frost action	Adequate shoring and control of seepage water (quicking)	Control of seepage water. Side slopes = angle of repose	Possibility of settlement due to vibratory loads and drawdown of water table
Saturated glacial till	May be frost susceptible in which case drainage will not prevent frost heave	Adequate shoring and control of seepage if any. In extreme depths, a possibility of bottom heave	Control of seepage water. Side slopes = 1½: 1 except for extremely deep excavations or where till is loose	If till is dense, a bearing capacity of 5T/sq ft can be expected. Little possibility of settlement except where till is very loose
Saturated silts and sandy silts	Drainage alone will not control frost action. Adequate non-frost-susceptible base must be used.	Adequate shoring—control of seepage pressure vital to prevent quick conditions	Control of seepage water and pressure vital. Side slopes subject to erosion	Bearing capacity limited. Subject to some settlement under static loads and drawdown of water table
Saturated silty clays and clays, varved clays	Frost susceptible. Safe height of fill limited by shear strength	Adequate shoring—control of seepage water—depth of open shaft limited by shear strength	Control of seepage water. Depth of excavation dependent on side slopes and shear strength. If LI exceeds 1, failure can be disastrous	Bearing capacity limited by shear strength and consolidation characteristics—heavy stockpiles subject to base failure
Muskeg	Route must be carefully selected to take advantage of most woody peats. High fills may require complete removal of peat. Grassy bogs if crossed must be excavated	Must be removed and site drained	Must be removed entirely or positively drained	Buildings should not be founded on peat—must be removed from site

be done in a natural depression, it is common practice to form "earth dams" with the tailings, gradually increasing the height of these dykes as storage increases. Care in the preparation of the site of such an artificial dam will always be necessary; study of the mechanical properties of the tailings, as deposited, will always be advisable since adequate dimensions for the cross-section of the dyke can then be determined and precautions taken against possible slope failures that can have serious consequences.

Conclusions

The object of this paper has been to indicate the nature of some of the soil problems that have been encountered by the Canadian mining industry, with special reference to the Precambrian Shield. Paradoxically, although rock conditions on the Shield are good on the whole, some of the most treacherous of all soils have been formed from these rocks. The drainage on the Shield is generally poor. The fine-grained soils usually have a low strength, high compressibility characteristics, and high sensitivities. Because of their high sensitivity, failure in fine-grained soils can have disastrous consequences.

During the exploration phase of a mining development, with slight additional expense, information can be obtained from which it is possible to anticipate generally the problems that may be encountered with soils. If bad or unusual soil conditions are indicated, expert assistance in design and construction should always be obtained. Continuing attention to all soils encountered in mining operations, however, on the part of all responsible for development work, is the best insurance for avoiding trouble. Recognition of soils as materials that can be tested and used to good advantage if only their properties are known can turn even the most serious potential soil problems into an engineering challenge.

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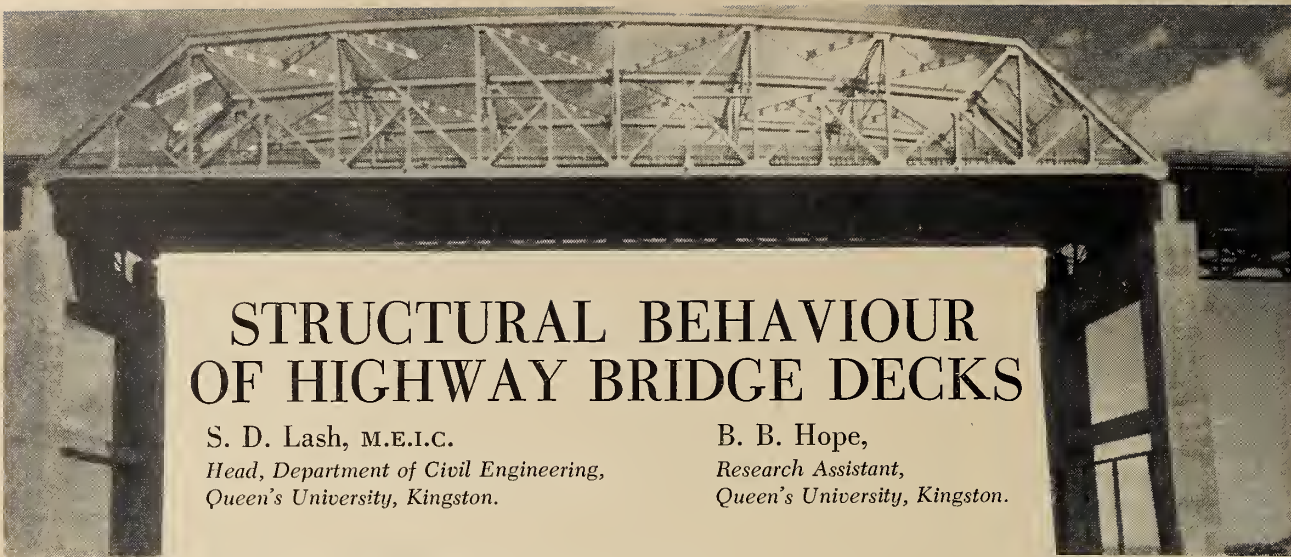

STRUCTURAL BEHAVIOUR OF HIGHWAY BRIDGE DECKS

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The paper describes a series of static tests carried out on the deck systems of three highway bridges. Two of the bridges were tested in the field and the third was re-constructed and tested in the Structural Engineering Laboratory at Queen's University. The two bridges tested in the field had 6 inch reinforced concrete slabs supported by steel stringers at 3 ft. 3 in. centres. The test results indicate that there is an appreciable amount of composite action present in this type of bridge even though shear connectors were not used. This composite action is due to friction between the slab and stringers and considerably reduces the stress in the stringers. The bridge tested in the laboratory had a laminated timber deck supported by steel stringers. Composite action was negligible. The experimental bending moments and deflections are compared with the theoretical values obtained using a method of harmonic analysis developed by A. W. Hendry and L. G. Jaeger. The agreement between the experimental and theoretical values of bending moment and deflections is good, especially for the laboratory bridge. It is concluded that the lateral distribution of concentrated loads may be estimated with reasonable accuracy by the Hendry and Jaeger method. For bridge decks of the type investigated this distribution is considerably more favourable than that indicated by current specifications. All three bridge decks carried relatively large loads, applied between the stringers, before local failures occurred.

A COMMON TYPE of bridge floor consists of a concrete slab or timber deck supported by a number of longitudinal steel beams (called stringers) which are supported either by the abutments of the bridge or by transverse floor beams. The elements of such a floor, i.e. the deck and the stringers, are usually designed by empirical rules and there is considerable uncertainty about the ultimate strength of the whole assembly. The tests described in this paper were carried out in order to provide further information in this matter.

A bridge floor may be regarded as an elastic plate of rather uncertain properties, supported by a series of elastic beams, which in turn may have elastic supports. The floor is required to carry both distributed and concentrated loads. There is usually some uncertainty about the degree of composite action that may exist between the deck and the beams, i.e. there may or may not be slip between the beams and deck. It will be obvious that any rigorous analysis of such a structure is bound to be complicated and must be based upon assumptions which may not correspond to actual conditions. Consequently it has become common practice in designing bridge floors to follow rules, which, although they lead to safe structures, result in unknown factors of safety.

Design Practice

The deck and stringers are usually designed for concentrated loads caused by vehicles. In designing decks, it is assumed that a wheel load is distributed longitudinally (i.e. in the direction of the stringer) over some effective width of deck. In designing stringers however, no longitudinal distribution is considered, but distribution may be assumed to take place laterally. The general specifications for highway bridges of the Department of Highways, Ontario, 1935 required interior stringers to be designed for a concentrated load of $1.3S/6$, i.e. $S/4.6$ times a wheel load for a concrete deck. S is the average spacing of the stringers in feet. For a laminated timber deck the fraction of a wheel load for which the interior stringers must be designed is $S/4$ provided S has a value of between 2 ft. and 4 ft. The Specification of the American Association of State Highway Officials (AASHO) 1953, gave corresponding figures of $S/5.0$ for a concrete deck and $S/4.25$ for a timber deck 6 in. thick. In the most recent AASHO Specifications (1957) the relative coefficient for a concrete deck is $S/5.5$ and that for a timber deck remains at $S/4.25$.

It should be noted that the expressions given for bending moments in interior stringers are intended to allow for loads from more than one wheel being transmitted to a particular stringer.

The allowable stress in stringers permitted by AASHO specifications is 18,000 p.s.i. for ordinary structural steel (ASTM A7) but a higher stress is permitted when determining the load capacity of an existing bridge. In a previous report Wright[1] has described in some detail the methods commonly used for rating existing bridges and has recommended a procedure based on separate load factors for live and dead load.[2] In North America, the most widely used method is that contained in the AASHO Specifications. These permit the "safe load-carrying capacity" of a bridge to be based on a stress of 0.82 times the assumed yield point of the material. For the ordinary grade of structural steel used (ASTM—A7) this would be 27,000 p.s.i.; for the steel used in older bridges, a stress of 24,600 (based on an assumed yield of 30,000) would commonly be assumed.

Theoretical Action

The following theoretical discussion concerns a concrete deck supported by stringers running longitudinally (i.e. in the direction of traffic). The discussion is valid nevertheless for a laminated timber deck though it must be appreciated that the moment of inertia in the longitudinal direction and the composite action are both zero. A laminated timber deck cannot, by virtue of its method of construction, contribute to the strength of the stringers and its sole function is to distribute the loads laterally to the neighbouring stringers.

Composite Action: Much experimental work has been done in the laboratory on composite action but this has tended to be concerned with beams in which there was little or no slip between steel and concrete. In a composite beam bridge shear connectors are usually provided so as to ensure that there is no slip and no tendency for the slab to lift away from the steel. In ordinary bridge floors with concrete decks where shear connectors are not provided there may still be some significant degree of composite action.

We are primarily concerned with the tensile stress in the lower fibre of the steel beam. If we neglect all composite action and assume that all the load is resisted by the steel beam:

$$f = (M/Z) = aM \quad (1)$$

If we neglect all composite action but assume that part of the moment is resisted by the slab then:

$$f = bM \quad (2)$$

If we assume full composite action:

$$f = cM \quad (3)$$

In a practical situation where there is partial composite action, we have:

$$f = dM \quad (4)$$

and we would expect "d" to have a value between "a" and "c". It will be convenient to express "d" as:

$$d = a + k(c - a)$$

and we will call k the "degree of composite action". For full composite action $k = 1$, for no composite action $k = 0$.

$$\text{in general,} \quad k = \frac{(a - d)}{(a - c)} \quad (5)$$

The values of a and c may be calculated by the usual methods, making some reasonable assumptions about the elastic moduli of the slab and beam. The value of d may be determined experimentally, if strains are known on the bottom and top surface of the steel beam. The theory is as follows:

Assume strains as shown in Fig. 1 are positive then slip $= \epsilon_t + \epsilon_{bc}$. Considering axial forces in the steel and the concrete.

$$T = \left(\frac{\epsilon_b - \epsilon_t}{2}\right) EsAs$$

$$C = \left(\frac{\epsilon_{tc} - \epsilon_{bc}}{2}\right) Ac\frac{Es}{n}$$

$$T = C$$

hence:

$$\epsilon_{tc} - \epsilon_{bc} = (\epsilon_b - \epsilon_t)n\frac{As}{Ac}$$

Assuming that the slab and the beam have the same curvature:

$$\frac{\epsilon_b + \epsilon_t}{d} = \frac{\epsilon_{tc} + \epsilon_{bc}}{t}$$

$$\epsilon_{tc} + \epsilon_{bc} = (\epsilon_b + \epsilon_t)\frac{t}{d}$$

The total moment of resistance, M is given by M = Moment in slab + Moment in beam + $T(t + d)/2$

$$M = \left(\frac{\epsilon_{tc} + \epsilon_{bc}}{2}\right) Ac\left(\frac{t}{6}\right)\frac{Es}{n} + \left(\frac{\epsilon_b + \epsilon_t}{2}\right) ZEs + \left(\frac{\epsilon_b - \epsilon_t}{2}\right) Es\,As\left(\frac{t + d}{2}\right)$$

which reduces to:

$$M = \frac{\epsilon_b + \epsilon_t}{2}\left[\frac{t^2}{6d}Ac\frac{Es}{n} + ZEs\right] + \frac{\epsilon_b - \epsilon_t}{2}\left[EsAs\frac{(t + d)}{2}\right]$$

$$= \epsilon_b\left[\frac{t^2}{12d}Ac\frac{Es}{n} + \frac{ZEs}{2} + EsAs\frac{(t + d)}{4}\right] + \epsilon_t\left[\frac{ZEs}{2} - EsAs\left(\frac{t + d}{4}\right)\right]$$

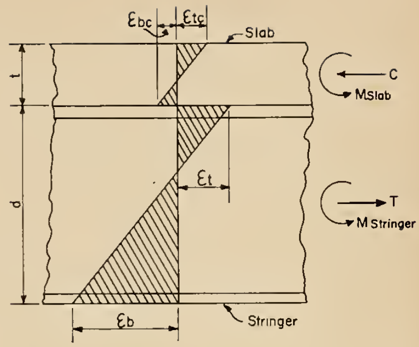


Fig. 1. Strains and Moments in a composite beam

For any particular structure this reduces to:

$$M = A\epsilon_b - B\epsilon_t \quad (6)$$

where A and B are coefficients.

Experimentally we can determine the ratio of ϵ_t to ϵ_b and hence we can express M as

$$M = C\epsilon_b$$

$$\text{or} \quad \epsilon_b = M/C$$

$$f_b = (E/C)M = dM \quad (4)$$

This theory may be modified if ϵ_t is measured at some point other than the upper surface of the top flange.

Load Distribution between Stringers:

i. *Introduction*

Theoretical studies of the load distribution between stringers have been made by many investigators and in some instances these have been supple-

Fig. 2. Three stringer bridge

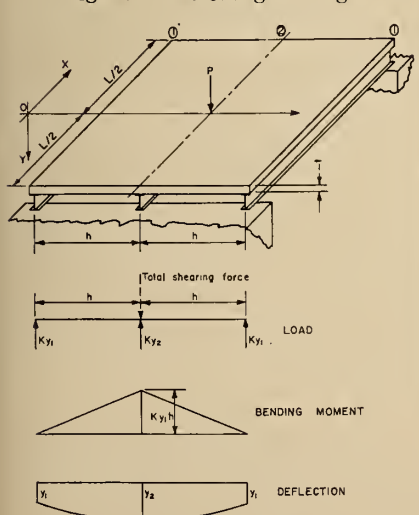


Table I
Tests of the Bannockburn Bridge

Type of Test	*Cycle*	*Location of Loading Pad (Refer to Fig. 8)*	*Load Increments (Kips)*	*Maximum Load (Kips)*	*Field Obesrvations and Remarks*
Flexural	I	1 and 2	10	50	
	II	3 and 4	10	50	
	III	2 and 3	20	80	
	IV	7 and 8	20	80	
	V	9 and 10	20	60	
	VI	5 and 6	20	60	
	VII	1, 2, 3 and 4	20	80	Rock anchor pulled out.
	VIII	3 and 4	40	110	Roch anchor pulled out.
	XI	5 and 6	40	110	Rock anchor pulled out.
	XII	14	40	110	Stringer yield at 106 kips. Circular cracks on top of slab. Slab pulls away from beam E at midspan (9/32″ gap). Rock anchor pulled at 110 kips.
Slab-Punching	IX	11	20	80	Slab failed suddenly in shear along beam E.
	X	12	20	98	Slab failed in shear along beam D.
	XIII	13	20	74	Slab failed in shear along beam A.

mented by experimental work using models.

Three main lines of investigation have been pursued.

(*a*) Extensive studies at the University of Illinois by Jensen, Newmark and others[3,4,5], lead to the development of a modified form of moment distribution. This is believed to be the basis of the AASHO specifications referred to previously.

(*b*) Massonet[6] and Guyon[7] have developed theoretical analyses based on the assumption that the slab and the stringers may be regarded as an anisotropic plate. The calculations are complicated but the results can be expressed in a series of simple design charts. These are currently used in Germany, Belgium and some other European countries.

(*c*) Hendry and Jaeger[8] have developed a method of harmonic analysis based on the assumption that the loading on stringers may be represented by a Fourier series. This method also leads to simple design charts and it has been found to be basically a simpler method to use where charts are not available than the two preceding methods.

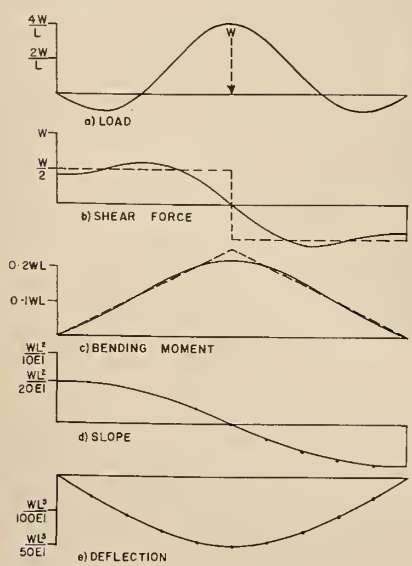
ii. Harmonic Analysis

The analysis of a bridge deck by harmonic analysis has been fully described in a recent book by Hendry and Jaeger[8] and it is therefore not necessary to repeat it here in detail. In principle, the method is as follows:

The loading on a simply supported beam is expressed as a series:

$$W = w_1 \sin \frac{\pi x}{L} + w_2 \sin \frac{2\pi x}{L} + \ldots + w_n \sin \frac{n\pi x}{L}$$

Fig. 3. Harmonic representation of a concentrated load



i.e.

$$W = \sum_{n=1,2,3}^{\infty} w_n \sin \frac{n\pi x}{L} \qquad (7)$$

With such a loading, shearing force (F) bending moment (M) slope (θ) and deflection (y) are given by:

$$F = \frac{L}{\pi} \sum_{n=1,2,3}^{\infty} \frac{w_n}{n} \cos \frac{n\pi x}{L} \qquad (8)$$

$$M = \frac{L^2}{\pi^2} \sum_{n=1,2,3}^{\infty} \frac{w_n}{n^2} \sin \frac{n\pi x}{L} \qquad (9)$$

$$\theta = \frac{L^3}{EI\pi^3} \sum_{n=1,2,3}^{\infty} \frac{w_n}{n^3} \cos \frac{n\pi x}{L} \qquad (10)$$

$$y = \frac{L^4}{EI\pi^4} \sum_{n=1,2,3}^{\infty} \frac{w_n}{n^4} \sin \frac{n\pi x}{L} \qquad (11)$$

The coefficients w_1, w_2 are evaluated by the usual procedure of Fourier analysis as:

$$w_n = \frac{2}{L} \int_0^L W \sin \frac{n\pi x}{L}\, dx \qquad (12)$$

Although several terms may be necessary in the series to give a reasonable approximation to a given loading, the equations for moment, slope and deflection converge very rapidly and a single term may represent deflection very closely.

The distribution of load between stringers is then determined by considering relative displacements of the slab and the stringers and the slab.

The slab will function to some extent as a plate and consequently some part

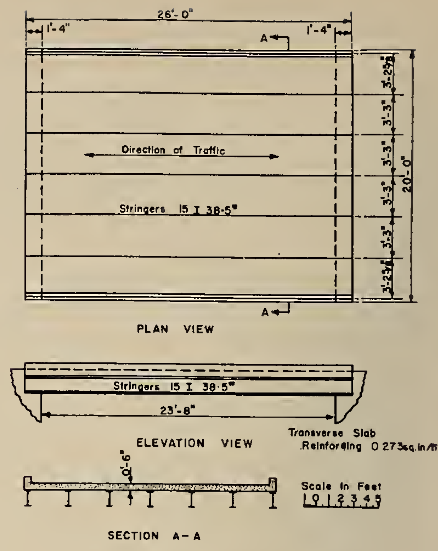


Fig. 4. Bannockburn Bridge

of the load P will be transmitted longitudinally to the end supports. (The amount to be transmitted will be increased if transverse supports are provided at the ends of the slab).

Hendry and Jaeger suggest that this may be estimated by assuming that the total load carried by the stringers is:

$$Ps = \left[\frac{nIs}{nIs + (ht^3/12)}\right] P \qquad (13)$$

where n is the modular ratio.

Alternatively, allowance may be made for the longitudinal moments carried by the slab by considering composite action.

Table II
Tests of the Poplar Hill Bridge

Type of Test	*Cycle*	*Location of Loading Pad (Refer to Figure 9)*	*Load Increments (Kips)*	*Maximum Load (Kips)*	*Field Observations and Remarks*
Flexural	I	1 and 2	20	80	
	II	3 and 4	20	80	
	III	2 and 3	20	140	
	IV	2 and 3	20	160	Continuation of cycle III.
	V	3	40	139.4	Stringer under the load yielded at a load of 139.4 kips.
	VI	6 and 7	20	100	
	VII	8 and 9	20	100	
	VIII	6 and 7	20	100	Results combined with cycle VI.
	IX	7 and 8	20	160	Maximum capacity of the loading system.
	X	8 and 9	20	140	Failure of the edge panel occurred about 12 mins. after application of the load.
	XI	6 and 7	20	140	There appeared to be no reduction in strength of this edge of the bridge as a result of the failure of the other edge in cycle X.
Slab-Punching	V	5	40	155.2	The slab failed in diagonal shear at a load of 155.2 kips. NOTE. The failure experienced in cycle X was a combination of slab-punching and lateral buckling of the edge stringer.

As an example of the method consider a slab resting on three simply supported stringers as shown in Fig. 2. The span of the stringers is L and their moment of inertia is I_s. The slab has a total thickness t and the spacing of the stringers is h.

Representing the deflection of each stringer by a Fourier series and considering the first term only we have if x be measured from mid-span:

$$y_1 = a_1 \cos \frac{\pi x}{L} \qquad (14)$$

$$y_2 = a_2 \cos \frac{\pi x}{L} \qquad (15)$$

y_1 and y_2 are the deflections of stringers (1) and (2) respectively: a_1 and a_2 are their mid-span deflections. The deflections are directly dependent upon loads and in general

$$EsIs \frac{d^4 y_1}{dx^4} = Ky_1 \qquad (16)$$

where K is a constant

From (14) and (16)

$$K = \frac{\pi^4 EsIs}{L^4} \qquad (17)$$

Consider a transverse strip of deck of unit width. It carries a central load Ky_2

Fig. 5. Poplar Hill Bridge and Laboratory Bridge
(Note: The dimensions in brackets refer to the Laboratory Bridge)

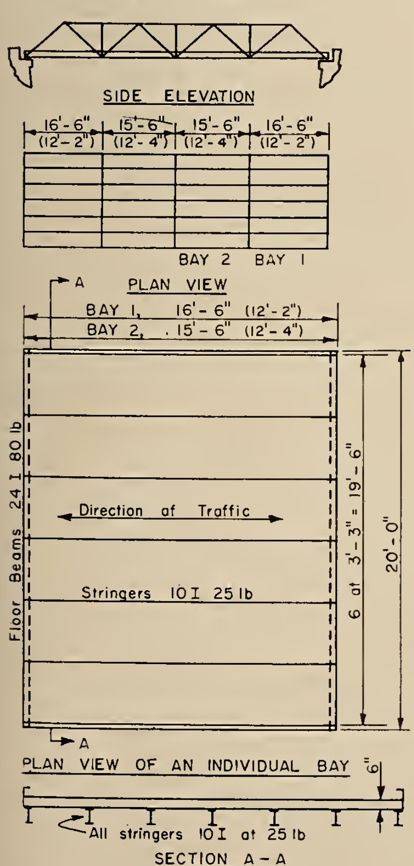


Table III
Tests of the Laboratory Bridge

Type of Test	*Cycle*	*Location of Loading Pad (Refer to Figure 10)*	*Load Increments (Kips)*	*Maximum Load (Kips)*
Flexural. Deck laminations perpendicular to the stringers.	I	1	10	30.0
	II	2	10	44.9
	III	3	10	42.1
	IV	4	10	50.0
	V	5	10	42.1
	VI	6	10	44.9
	VII	7	10	30.0
Flexural. Deck laminations at 45 degrees to the stringers	VIII	2	10	41.9
	IX	3	10	37.4
	X	4	10	43.6
	XI	5	10	39.6
	XII	6	10	40.3
Punching	XIII	8	10	48
	XIV	9	10	50

and has a net deflection $y_2 - y_1$. Then from moment areas:

$$\frac{Ky_1 h^3}{3EcIc} = y_2 - y_1$$

substituting

$$K = \frac{\pi^4 EsIs}{L^4} \qquad (18)$$

and letting

$$\alpha = \frac{12}{\pi^4}\left(\frac{L}{h}\right)^3 \frac{LEcIc}{EsIs}$$

we get

$$\frac{4y_1}{\alpha} = y_2 - y_1$$

and

$$a_1 = a_2\left(\frac{\alpha}{4 + \alpha}\right)$$

$$y_1 = \frac{\alpha}{4 + 3\alpha} A \cos \frac{\pi x}{L} = \rho_1 A \cos \frac{\pi x}{L} \qquad (19)$$

or

$$y_2 = \frac{4 + \alpha}{4 + 3\alpha} A \cos \frac{Wx}{L} = \rho_2 A \cos \frac{\pi x}{\pi} \qquad (20)$$

where $\quad A = a_2 + 2a_1$

"A" would be the amplitude if one of the stringers carried all the load, hence ρ_1 and ρ_2 indicate the proportions of the first harmonic of the deflection curve carried by each stringer. They are therefore called "distribution coefficients". If the deflection of the loaded girder is given by terms such as $\cos p\pi x/L$ or $\sin p\pi x/L$ distribution coefficients may be found by substituting α/p^4 for α in the formulas for first harmonic coefficients. In this way we can obtain the deflection curve for each stringer no matter what load may be applied. Similarly, we can determine the distribution of load, shear or bending moment. In practice, it is only necessary to distribute a limited number of harmonics because coefficients for the unloaded girders decrease very rapidly, i.e. the loading components represented by the higher harmonics are mostly retained in the loaded girder.

As an example let us assume that a single concentrated load is applied at mid-span of the middle stringer.

The load may be expressed as:

$$W = \frac{2P}{L}\left[\sin\frac{\pi x}{L} - \sin\frac{3\pi x}{L} + \sin\frac{5\pi x}{L} + \ldots\right] \qquad (21)$$

Obviously this equation does not represent a concentrated load at all closely (see Fig. 3) but if integrated, it will describe very accurately the deflection curve of a beam carrying the concentrated load and consequently it may be used to determine distribution coefficients:

if $\qquad \alpha = 1$

then:

$$\rho_1 = \frac{\alpha}{4 + 3\alpha} = 0.143 \qquad (22)$$

$$\rho_2 = \frac{4 + \alpha}{4 + 3\alpha} = 0.714 \qquad (23)$$

Thus, if only the first harmonic be considered, 71.4% of the load is carried by the central beam. Considering the third harmonic, (the second harmonic is zero with the load at midspan) ($p = 3$) and substituting $\alpha^1 = \alpha/p^4$ we get $\rho_1 = 0.003$, from which we find that the load carried by the central beam is (0.714 – 0.003) 100 or 71.1% of W. It is unnecessary to consider further terms in the series. The assumption $\alpha = 1$ in this example corresponds to a relatively flexible slab. If we take $\alpha = 10$, we find, considering the first harmonic only, that 41.2% of the load is carried by the central beam. Considering the third harmonic makes more difference in this case and gives 38.4% on the central beam.

The distribution coefficients depend only upon α which has been defined as

$$\frac{12}{\pi^4}\left(\frac{L}{h}\right)^3 \times \frac{LE_cI_c}{E_sI_s}$$

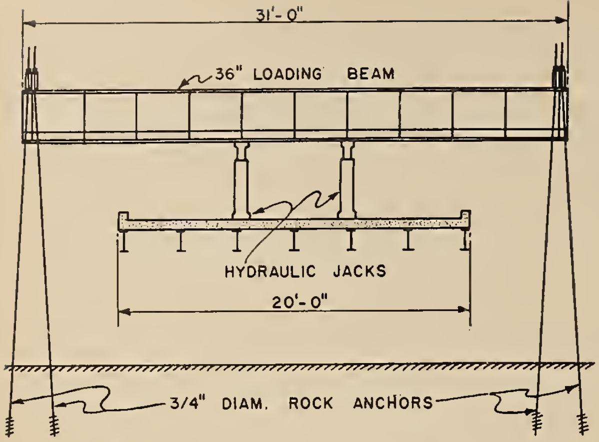


Fig. 6. Arrangement of the loading system (Note: At Poplar Hill and in the Laboratory the tie rods were anchored under the floor beams)

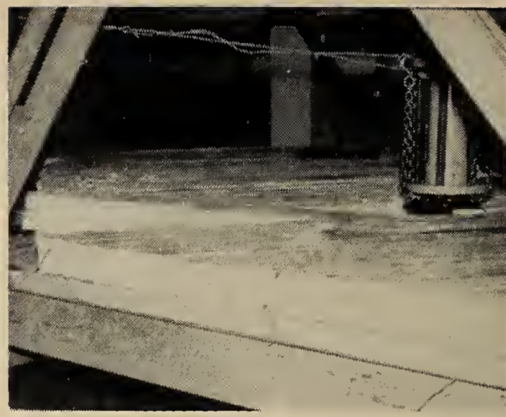


Fig. 7. Photograph of the deck after local failure of the timber laminations

and in this expression the only uncertainty concerns the value of E_cI_c/E_sI_s.

The value of E_c, the modulus of elasticity of the concrete may be uncertain and as with all reinforced concrete members, there is likely to be great doubt as to the appropriate value of I_c. Should concrete in tension (which may be cracked) be included and should any allowance be made for reinforcement?

As far as longitudinal moments are concerned, these questions have been answered by assuming that the moment of inertia of the slab is $ht^3/12$, i.e. considering the full section to be effective and ignoring the reinforcement. These assumptions may be less reasonable for transverse moments.

In the preceding discussion, it was assumed that the stringers have no torsional rigidity and where I-beams are used this is a reasonable assumption. Hendry and Jaeger show how allowance may be made for any assumed degree of torsional stiffness. This has more application to construction using concrete stringers than to I-beam floors.

The method used for a three-stringer bridge may be extended to bridges having four, five or six stringers and Hendry and Jaeger give distribution coefficients for such bridges.

Observing that

$$\alpha = \frac{12}{\pi^4}\left(\frac{L}{h}\right)^3 \frac{E_cI_cL}{E_sI_s}$$

and assuming that the stringer may be replaced by a uniform plate of effective width B_e where $B_e = Nh$, N being the number of stringers, we have

$$\alpha_N = \frac{12}{\pi^4}\left(\frac{L}{B_e}\right)^3 \times N^4 \times \frac{\text{Total transverse } EI}{\text{Total Longitudinal } EI}$$

L/B_e and the ratio of total transverse EI to total longitudinal EI are the same in the uniform plate and in the bridge with N^1 stringers from the relationship

$$\alpha_{N^1} = \alpha_N \left(\frac{N^1}{N}\right)^4$$

For beams that are not simply supported, loads may be expressed as a series of components each component having the property of the equations given above that the deflection form is similar to the load form. Such components are called "basic functions" ($F(x)$) and they must satisfy the equation

$$\frac{d^4F(x)}{dx^4} = KF(x)$$

which is satisfied in general by :

$$F(x) = A \operatorname{Cosh} \theta x + B \operatorname{Sinh} \theta x + C \operatorname{Cos} \theta x + D \operatorname{Sin} \theta x$$

where $\theta^4 = K$ and A, B, C, D are constants.

Of the four constants, three may be considered as determining the shape of the basic function and the remaining one as determining its magnitude. In analysis, D is assumed to be unity. For bending moments, it is convenient to introduce supplementary functions. The supplementary functions are the same as the basic functions except for a change of sign in the cosine terms. Then :

$$-M = \frac{w_1}{\theta_1^2}\Phi_1(x) + \frac{w_2}{\theta_2^2}\Phi_2(x) + \ldots + \frac{w_n}{\theta_n^2}\Phi_n(x)$$

Similarly other supplementary functions are introduced in the series for shear and slope.

Research Problems: Although theoretical solutions, such as those described above, appear to offer a reasonable approach to the problem of analysing the effects of concentrated loads on bridge floors, there must be considerable doubt as to whether such solutions can be

Table IV
Bannockburn Bridge
Degree of Composite Action at Mid-Span

Stringer	*Loading Cycle* *I II VIII*	*III*	*IV*	*V*	*VII*
A	.24	.43	.69	—	.53
B	.37	.24	.34	—	.44
C	.30	.26	.19	—	.40
D	.37	.23	.23	.56	.30
E	.53	—	—	.63	—
F	(.77)	—	—	.30	—
G	(.96)	—	—	.31	—

Table V
Poplar Hill Bridge
Degree of Composite Action at Mid-Span

	Loading Cycle						
	End Panel				*Interior Panel*		
Stringer	*I II*	*III*	*V* (*40 kips*)	*V* (*120 kips*)	*VIII X*	*IX*	*XI*
A	1.03	0.91	0.98	0.98	0.85	0.87	0.87
B	1.01	0.93	1.08	1.08	0.82	0.86	0.89
C	1.01	0.92	0.61	0.61	0.60	0.65	0.77
D	0.98	0.85	0.92	0.89	0.77	0.79	p.75
E	—	—	0.89	0.85	0.71	—	0.76
F	—	—	0.89	0.88	0.91	—	0.77
G	—	—	1.04	0.89	—	—	—

properly applied to actual structures. It is therefore desirable to carry out full scale tests.

The chief points of uncertainty are the following:

(a) What degree of composite action exists in a typical floor without shear connectors;

(b) To what extent are concentrated loads distributed between stringers. Can theoretical solutions be made applicable to existing structures on the basis of reasonable assumptions concerning elastic constants, moments of inertia and composite action.

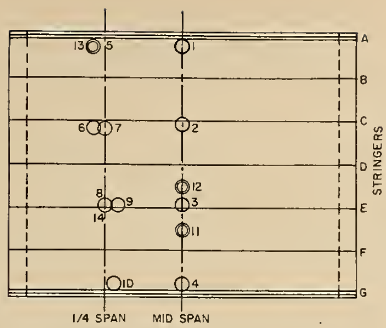


Fig. 8. Locations of loads—Bannockburn Bridge

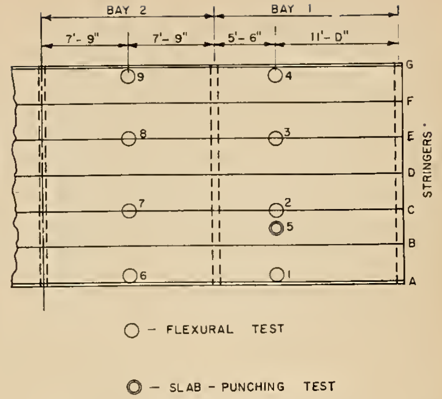


Fig. 9. Location of loads — Poplar Hill Bridge

Full Scale Tests

Description of Bridges tested in the Field: Two bridges were tested — one at Bannockburn, Ontario, and the other at Poplar Hill, Ontario.

The Bannockburn bridge had a single span of 23.4 ft. between abutments and consisted of seven 15 in. I-beam stringers supporting a 16 in. concrete slab.

The Poplar Hill bridge had a single span of 64 ft. It consisted of two trusses which supported floor beams at panel points which in turn supported stringers and a concrete slab. Tests were made of the strength of the floor but the trusses were not loaded. Details of the bridges are shown in Fig. 4 and 5.

The floors of the two bridges were similar in many ways. Both had relatively closely spaced stringers supporting a 6 in. slab. In the Bannockburn bridge, the stringers were supported directly on the abutments of the bridge; at Poplar Hill they were supported by floor beams. The slab at Bannockburn was about 30 yr. old but was in good condition. It appeared to be separated from the stringers by a layer of paper used as a form liner. The slab at Poplar Hill had been replaced six years previously and was in excellent condition. There were no shear connectors in either floor.

The floors were loaded by four 50 ton jacks resting of 15 in. diam. steel plates and arranged so as to simulate loads produced by the rear wheels of trucks. The reaction of the jack was taken by a large beam spanning the bridge transversely. The reaction from this beam was taken by short cross beams at the ends which were anchored by tie rods. At Bannockburn, these tie rods were anchored in the ground; at Poplar Hill they were attached to the floor beams of the bridge. The general arrangement of the testing equipment is shown in Fig. 6 and 7.

Strains were measured on the stringers by electrical resistance gauges. The location of these gauges at Poplar Hill was on the outer face of the lower flange, and the inner face of the upper flange at the mid span and ends of each stringer. At Bannockburn the gauges were located at the mid span and quarter span of the stringers. In addition, at Bannockburn, strains on the concrete slab were measured using a mechanical demountable strain gauge (DEMEC). An attempt was made to measure slip between the stringers and the slab at a number of places on both bridges.

Description of the Bridge tested in the Laboratory: The bridge tested in the laboratory was originally located on a County Road south of Napanee and was called the 'Big Creek Bridge'. This bridge was dismantled and re-erected using high-strength bolts in the Structural Engineering Laboratory

Table VI
Bannockburn Bridge
Comparison of Experimental and Theoretical Mid-Span Bending Moments in Stringers

Axle Load 40 Kips
A. Load Applied at Mid-span

Stringer	Exp. Bending Moment Kips Ft. M_1	Theo. Bending Moment Kips Ft. M_2	M_1/M_2
Cycles I, II, and VIII (Loads on Stringers A and C).			
A	66.4	75.5	0.88
B	47.6	53.3	0.89
C	40.6	45.0	0.90
D	21.9	25.7	0.82
E	8.8	11.7	0.75
F	1.5	2.6	0.58
G	0.0	3.0	—
Cycle III (Loads on Stringers C and E)			
A and G	12.9	12.4	1.03
B and F	21.6	26.0	0.83
C and E	42.0	44.4	0.95
D	39.2	45.1	0.87
Cycle VII (Loads on Stringers A, C, E and G)			
A and G	66.8	72.5	0.92
B and F	54.4	55.6	0.97
C and E	49.4	56.7	0.87
D	45.4	51.5	0.88

B. *Load Applied at Quarter Span*

Stringer	Exp. Bending Moment Kips Ft. M_1	Theo. Bending Moment Kips Ft. M_2	M_1/M_2
Cycle IV. (Loads on Stringers C and E)			
A and G	13.8	8.7	1.60
B and F	13.1	16.2	0.81
C and E	14.2	24.7	0.67
D	17.9	26.2	0.68
Cycle V (Loads on Stringers E and G)			
A	0.0	2.3	—
B	1.9	1.9	1.00
C	7.2	9.1	0.79
D	12.8	17.6	0.73
E	18.2	26.9	0.68
F	28.6	37.4	0.77
G	35.3	47.2	0.75

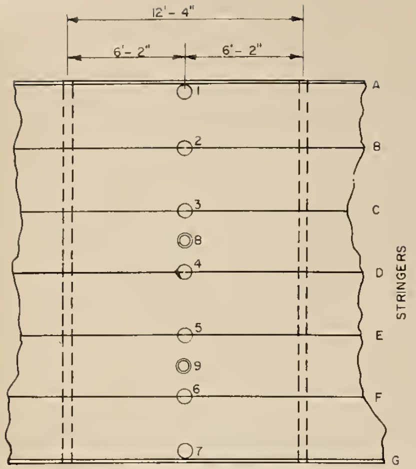


Fig. 10. Location of loads—Laboratory Bridge

at Queen's University in April and May, 1959.

The Laboratory Bridge was of the same type as the Poplar Hill Bridge previously described but had a span of 48 ft. Details of the bridge are shown in Fig. 5.

Two types of timber deck were tested, the first consisting of 2 in. by 6 in. spruce joists laid on edge and spanning the stringers perpendicularly, the second consisting of 2 in. by 6-in. spruce joist laid on edge and spanning the stringers transversly at an angle of 45° to them. The laminations were nailed together sing 5 in. nails at 12 in. centres and were arranged so that at least 3 out of 4 laminations were continuous between any pair of stringers.

The loading arrangement was essentially the same as that used at Poplar Hill although only one hydraulic jack was used throughout the tests

Strains were measured, using electrical resistance gauges, at the outside face of the lower flanges and the inside face of the upper flanges of the stringers at the mid span of each stringer and at the ends of the centre stringer and the edge stringers.

Test Procedures: Most of the field tests consisted of applying loads in pairs (representing two wheels on an axle), the loads being applied above the interior stringers and adjacent to exterior stringers. Separate tests were carried out in which a single load was applied to the slab between a pair of stringers — these are referred to as "slab punching" tests.

The complete program of field tests is summarized in Tables I and II and Fig. 8 and 9.

The laboratory tests consisted of applying a single load above the interior stringers. When an edge stringer was loaded the jack was placed on the deck adjacent to the stringer. 'Punching' tests were also performed by applying a single load to the deck between a pair of stringers. The program of tests for both decks was identical and the tests are summarized in Table III and Fig. 10.

Table VII
Polar Hill Bridge
Comparison of Experimental and Theoretical Mid-Span Bending Moments in Stringers

Axle Load 80 kips

A. *End Panel: Loads Applied at Third Point of Span*

Stringer	*Exp. Bending Moment Kips Ft.* M_1	*Theo. Bending Moment Kips Ft.* M_2	M_1/M_2
	Cycles I and II (Loads on Stringers A and C)		
A	47.1	82.8	0.57
B	57.4	67.5	0.85
C	38.1	52.3	0.73
D	29.7	27.8	1.06
E	20.1	18.5	1.08
F	10.1	2.0	5.0
G	5.2	0.0	—
	Cycle III (Loads on Stringers C and E)		
A and G	11.2	12.8	0.88
B and F	32.1	27.9	1.14
C and E	38.4	48.8	0.79
D	43.2	53.4	0.81
	Cycle V (Load on Stringer E—80 kips)		
A	5.0	0.0	—
B	17.6	11.6	1.53
C	31.6	27.8	1.14
D	55.2	53.4	1.03
E	58.8	69.8	0.85
F	57.5	53.4	1.08
G	13.1	25.6	0.51

B. *Interior Panel: Loads Applied at Mid-Span*

Stringer	*Exp. Bending Moment Kips Ft.* M_1	*Theo. Bending Moment Kips Ft.* M_2	M_1/M_2
	Cycles VIII and X (Loads on Stringers A and C)		
A	70.4	103.6	0.68
B	73.5	69.4	1.05
C	57.6	68.2	0.86
D	31.0	32.0	0.94
E	17.0	16.4	1.03
F	8.3	3.8	2.18
G	0.0	0.0	—
	Cycle IX (Loads on Stringers C and E)		
A and G	14.8	12.6	1.18
B and F	40.0	31.6	1.26
C and E	54.4	66.8	0.82
D	60.4	60.6	1.00
	Cycle XI (Loads on Stringers E and G)		
A	0.0	0.0	—
B	10.1	3.8	2.65
C	20.2	16.4	1.23
D	27.2	32.8	0.83
E	44.6	68.2	0.65
F	79.3	69.4	1.14
G	69.7	103.6	0.67

Test Results:

i. Ultimate Strength

The Bannockburn bridge was designed for an H-15 loading, the critical load on the stringers being two axle loads of 24 kips each. The stress produced by this load plus dead load assuming the effective wheel load to be given by S/4.6 was 13.4 ksi. Increasing the live load by 30% for impact gave a stress of 16.6 ksi.

The bridge actually supported a test load consisting of two axle loads of 80 kips each applied at mid-span without any signs of distress. A greater load could not be applied at this location owing to weakness in the anchorages of the reaction beam. On the basis of strain measurements, it would appear that the bridge could have carried a single axle load of 160 kips applied at mid-span. Yielding of a stringer occurred under a single wheel load of 106 kips applied over an interior stringer at quarter span. A wheel load of 74 kips applied to the slab near to an exterior stringer produced a local slab failure.

A specification for rating existing bridges proposed in a previous report by Wright[2] was based on explicit load factors of 1.10 for dead loads and 1.25 for live loads. On this basis but omitting any allowance for impact the permissible axle load would be 56.8 kips. The tests show that the actual load factor on live load would be close to four.

The Poplar Hill bridge was apparently designed to carry a 15 ton traction engine with 10 tons on the rear wheels and 5 tons on the roller. The stress produced by this load plus dead load assuming the effective wheel load to be given by S/4.6 was 16.1 ksi. It would appear that no allowance was made for impact. The stress that would have been produced by an H-15 loading assuming the same distribution of load and making no allowance for impact was 19.6 ksi. With impact at 30%, the stress would have been 24.8 ksi.

The bridge supported a test axle load of 160 kips applied at mid-span of an interior panel without any signs of distress. Yielding of a stringer occurred under a single wheel load of 139 kips applied over the third point of an interior stringer of an end span. A wheel load of 155 kips applied to the slab midway between two interior stringers produced a local slab failure and wheel load of 70 kips applied to the slab near to an exterior stringer produced a local slab failure.

It will be clear from the above figures that both bridges could carry static loads about six times as great as those they were originally designed to carry and that under loads of normal magnitude, the stresses in the stringers were relatively small. It is evident that bridge floors of the slab and stringer type are considerably stronger than conventional calculations indicate. It should be noted also that in each bridge, the weakest part of the structure was the slab near to an exterior stringer.

The reasons for this increase in strength will become evident when the deflection and strain readings are examined in detail.

ii. Loads Transmitted Longitudinally by the Slab

As might be expected, the effect of loading the concrete slab is to deflect it into a saucer shape. This was indicated clearly by the measured

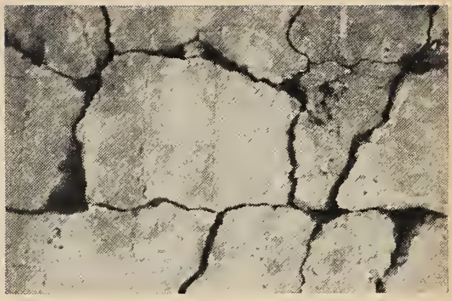


Fig. 11. Photograph of the underside of the deck after local failure of the concrete slab

deflections. It is not possible to arrive at any realistic estimate of the moments in the slab from its deflection or curvature because of uncertainty about the proper value of *I*. The moments of inertia of an uncracked 6 in. slab are 216 in.[4] per ft. of width, neglecting the effect of reinforcement, whereas, if concrete in tension be neglected and reinforcement included, (say ½ in. diam. at 8 in. centres) the moment of inertia is 55 in.[4] There is also uncertainty, though not so much, about the proper value of *E*.

In view of the complexity of plate analysis, it is better to take account of longitudinal moments in the slab by considering the bending of a stringer and slab together; this may be done by considering composite action between the two. If we compare a stringer having composite action with one in which such action is absent (Fig. 1) it will be apparent that the composite action results in an axial compression in the slab. This will reduce the tendency of the slab to crack and hence will increase the proportion of the load tranmitted longitudinally by the slab.

iii. Composite Action

In both bridges, direct measurements were made of slip between the top flange of the steel and the bottom of the concrete slab. These slip gauges showed that slip started to occur as soon as the first load was applied. Evidently there was little if any adhesion between the concrete and the steel. At Bannockburn, it may be assumed that none ever existed because there was paper adhering to the bottom of the slab. At Poplar Hill, there may have been adhesion at some time, but presumably as a consequence of traffic loading this had disappeared by the time of the test. Neither bridge therefore would normally be considered to be of composite construction. In spite of this there is clear evidence that in both bridges there was an appreciable amount of composite action which must have been due to friction between steel and concrete.

Table VIII
Bannockburn Bridge
Comparison of Experimental and Theoretical Mid-Span Deflections in Stringers

Axle Load 40 Kips

A. *Load Applied at Mid-Span*

Cycles I, II and VIII (Loads on Stringers A and C)

Stringer	*Exp. Deflection Ins.* d_1	*Theo. Deflection Ins.* d_2	d_1/d_2
A	0.248	0.310	0.80
B	0.206	0.232	0.88
C	0.164	0.180	0.81
D	0.099	0.111	0.89
E	0.044	0.054	0.82
F	0.013	0.009	1.45
G	0.017	0.018	0.95
Cycle III (Loads on Stringers C and E)			
A and G	0.038	0.054	0.70
B and F	0.096	0.113	0.85
C and E	0.143	0.175	0.82
D	0.153	0.190	0.80
Cycle VII (Loads on Stringers A, C, E and G)			
A and G	0.222	0.295	0.75
B and F	0.201	0.242	0.83
C and E	0.194	0.233	0.84
D	0.186	0.222	0.84

B. *Load Applied at Quarter-Span*

Cycle IV (Loads on Stringers C and E)

Stringer	*Exp. Deflection Ins.* d_1	*Theor. Deflection Ins.* d_2	d_1/d_2
A and G	0.031	0.034	0.80
B and F	0.066	0.079	0.84
C and E	0.092	0.116	0.79
D	0.106	0.135	0.79
Cycle V (Loads on Stringers E and G)			
A	0.003	0.013	0.23
B	0.008	0.009	0.89
C	0.032	0.042	0.76
D	0.070	0.085	0.83
E	0.117	0.135	0.87
F	0.158	0.179	0.84
G	0.190	0.233	0.82

Table IX
Poplar Hill Bridge
Comparison of Experimental and Theoretical Mid-Span Deflections in Stringers

Axle Load 80 kips

A. *End Panel: Loads Applied at Third Point of Span*

Cycles I and II (Loads on Stringers A and C)

Stringer	*Exp. Deflection Ins.* d_1	*Theo. Deflection Ins.* d_2	d_1/d_2
A	0.192	0.261	0.74
B	0.197	0.210	0.94
C	0.178	0.163	1.10
D	0.115	0.087	1.33
E	0.068	0.029	2.43
F	0.040	0.007	5.71
G	0.028	0.014	2.00
Cycle III (Loads on Stringers C and E)			
A and G	0.048	0.041	1.18
B and F	0.130	0.101	1.18
C and E	0.200	0.152	1.31
D	0.201	0.166	1.21

B. *Interior Panel: Loads Applied at Mid Span*

Cycles VIII and X (Loads on Stringers A and C)

Stringer	*Exp. Deflection Ins.* d_1	*Theor. Deflection Ins.* d_2	d_1/d_2
A	0.250	0.254	1.01
B	0.280	0.190	1.45
C	0.273	0.156	1.75
D	0.171	0.087	1.97
E	0.100	0.035	2.78
F	0.042	0.000	—
G	0.009	0.000	—
Cycle IX (Load on Stringers C and E)			
A and G	0.052	0.018	2.90
B and F	0.128	0.085	1.50
C and E	0.220	0.154	1.43
D	0.205	0.163	1.26

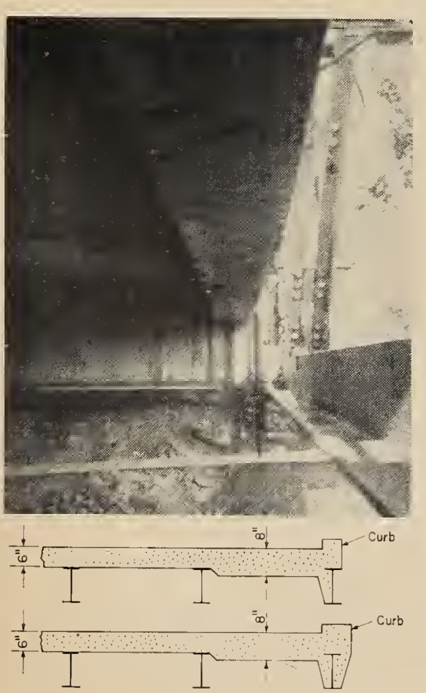
The "degree of composite action" has been determined from the strain measurements made on the steel stringers and the results are given in Tables IV and V.

At Bannockburn, the minimum degree of composite action was about 20% and the average, excluding very lightly loaded stringers, was about 37%. At Poplar Hill, the minimum was about 60% and the average based on 131 observations was 91%. It seems clear that composite action is a factor of major importance in bridge floors of the kind tested. Anything that improves composite action will materially diminish the tensile stresses in the steel produced by static loads. It is important therefore not to paint the top of the beam, to avoid coating it with form oil and not to put any paper of any kind on top of it.

iv. Load Distribution: Stringers stressed below yield

The distribution of loads between stringers may be determined from the experimental results in various ways. Thus we can readily compare deflections, bending moments or maximum strains. It is probably most convenient to compare bending moments and this has been done in Tables VI and VII. These tables show the bending moments calculated from the observed strains and compare them with the theoretical values given by the Hendry and Jaeger theory. In both sets of values, a modular ratio of 10 was assumed, but a different value could have been used without materially affecting the results. For the purpose of computing the parameter a, it was assumed that the slab was uncracked. In preparing these tables comparable results have been averaged wherever possible. This averaging consists of (a) averaging the results of tests which were repeated, and (b) averaging results in stringers symmetrically located with respect to the load. In addition, graphs were drawn showing the relation between load and strain, and these have been corrected when necessary to allow for apparent zero errors. In general it may fairly be said that provided the stringers were not strained to yield, the load-strain graphs were straight lines.

Fig. 12. Edge stringer failure and suggested methods for strengthening the edge panel



The results for the Bannockburn bridge show an excellent agreement for all tests in which the loads were applied at mid-span. The agreement is not close for loads applied at quarter span but the moments calculated from the observed strains are in all cases appreciably smaller than those indicated by theory. It seems probable that the difference was caused by the presence of some restraint at one end of the bridge.

At Poplar Hill, the concrete slab was continuous from one end of the bridge to the other. It therefore seemed reasonable in the first instance to calculate moments in the stringers on the basis of fixed ends at interior supports and then to modify the results by moment distribution. The calculations were lengthy and the agreement with observed moments was not close. On examining the deflection graphs it became clear that there were no points of contraflexure, and much better agreement was obtained by assuming the stringers to have simply supported ends. The reasons for this behaviour are not clear but two explanations are possible:

a. the slab had cracked over the supports;
b. owing to absence of adhesive bond the slab in unloaded spans separated from the beams.

It was not possible to check these ideas in the field. The slab was covered with an asphalt pavement so that cracking of the top surface could not be observed. No actual separation of slab and stringer in unloaded spans was observed but this could easily have occurred without detection.

On examining the results more closely, it will be evident that in a few instances there was a large percentage difference between theory and practice. This was particularly true at Poplar Hill. These large discrepancies occur either in stringers which are remote from the loading points and hence carry small loads only, or on edge stringers. As far as the edge stringers are concerned, it was not possible to apply loads directly above them and so the theoretical results are not strictly applicable.

At Bannockburn, the greatest moment for a 40 kip axle load occurred on an edge stringer. At Poplar Hill, it occurred on the first interior stringer. These maximum moments may be compared on the basis of an empirical distribution factor similar to that given in the AASHO Specifications. If we let the fraction of a wheel load for which stringers should be designed be S/X, then considering the most heavily loaded stringers at Bannockburn, X was 6.3 and at Poplar Hill, X was 6.4. For practical purposes it would seem not unreasonable to assume $X = 6.5$. Admittedly this assumption involves a slight underestimate of the possible maximum moment but this underestimate may be justified if ultimate strength rather than elastic conditions are considered.

v. Load distribution—Stringer stressed to Yield

It proved to be somewhat difficult to apply sufficient load to the Bannockburn bridge to cause yield owing to the inadequacy of the rock anchors. Yield, however, was reached when a single load of 106 kips was applied at the quarter span of Stringer E.

The load required to produce yield at 30 ksi. assuming a degree of composite action (k) of 0.20 was 113 kips which agrees reasonably well with the observed values.

Yield of the stringer caused extensive cracking of the slab on the underside in the vicinity of the load and on the top of the neighbouring beams. Consequently, the slab was no longer so effective in distributing load, and therefore relatively large deflections of the overloaded stringer resulted. The slab and the stringer separated at mid-span by about ¼ in. In spite of this, complete collapse of the bridge did not result and it was possible to increase the load to 110 kips before the anchorage failed. Presumably, the plastic moment capacity of the stringer was sufficient to carry the imposed loads. However, it is imporant to realize that yield of a stringer will cause local failure of the slab, and that this in turn will throw additional load on to the stringer.

At Poplar Hill, yield of a stringer occurred under a single load of 140 kips applied at the one-third point of an interior stringer in the end bay. The calculated load to produce yield, assuming a yield stress of 33 ksi. and a degree of composite action (k) of 0.80 was 132 kips.

The Poplar Hill bridge carried an axle load of 160 kips applied at midspan of an interior bay over interior stringers without *visual* evidence of yield. Under this load however, the bottom fibres of the two stringers under the load points yielded. The calculated axle load to produce yield assuming a yield stress of 33 ksi. and a degree of composite action (k) of 0.80 was 158 kips.

vi. Deflections

The deflection of any stringer depends upon the load it carries and its moment of inertia. The load may be determined in the same way as the bending moment by harmonic analysis and the same distribution coefficients will apply: the moment of inertia will be greatly influenced by composite action. As an approximation, it will be assumed that the moment of inertia is modified by composite action in the same way as the section modulus.

Then: I effective $= I_s + k(I_{cs} - I_s)$

where I_s is the moment of inertia of the slab only, I_{cs} is the moment of inertia of the composite section expressed in steel units using an appropriate modular ratio,

and k is the degree of composite action as previously defined.

Table VIII compares observed deflections at Bannockburn with calculated values assuming a modular ratio of 10 and a degree of composite action (k) equal to 0.3. There is good agreement especially if relative values of stringer deflections are considered. On an absolute basis the agreement may also be considered fairly good, the average ratio of experimental to observed deflection being 0.84.

The results from the Poplar Hill test (Table IX) are less satisfactory. The assumption of a modular ratio of 10 and a degree of composite action of 0.90 leads to an underestimate of deflections of about one third. In order to obtain good agreement a smaller value of stiffness must be assumed. This may be obtained by assuming a larger value of modular ratio or a smaller degree of composite action. It should be noted that the slab at Poplar Hill was about the same as the slab at Bannockburn but the stringers were made smaller, hence the relative effect of an erroneous assumption concerning the slab would be much greater with the Poplar Hill bridge.

The figures given for Poplar Hill refer to an axle load of 80 kips as

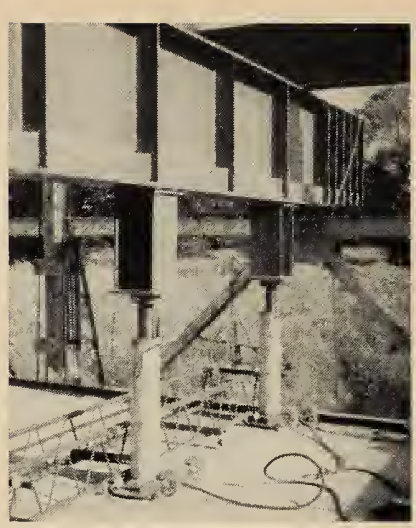


Fig. 13. Photograph of the loading system

compared with 40 kips at Bannockburn. The agreement between observed and calculated deflections is better for smaller loads. As loads are increased the slab cracks in both directions — cracks parallel to the stringers cause a modification of the distribution of load i.e. at higher loads there is less distribution; cracks at right angles to the stringers reduce the effective I of the composite section and hence result in larger deflections.

vii. Effects of Concentrated Loads Applied between Stringers

At each bridge, a number of tests were carried out in which concentrated loads were applied between stringers. These loads were of sufficient magnitude to cause failure of the slab and in some instances the adjoining stringers. (See Fig. 11 and 12).

At Bannockburn, three such tests were made and slab failure resulted at loads of 80, 98 and 74 kips. The smallest figure resulted from applying the load close to an exterior stringer. At Poplar Hill, only one test of this kind was made and failure occurred between two interior stringers at a load of 154 kips. In a later test using two wheel loads, one of which was applied near to an exterior stringer, failure occurred at a total load of 140 kips or a wheel load of 70 kips. A load of 70 kips on the 15 in. diam. loading pad corresponds to a pressure of 396 p.s.i. This is substantially higher than the pressure generally exerted by a truck wheel. Some caution must however be used in drawing conclusions from these results. Different results might have been obtained with different sized loading plates or with small changes in the location of loads.

AASHO Specifications require such slabs as those we are considering to be designed for a moment per foot width of $\pm P_1S/E$ where P_1 is the wheel load, S the effective span of the slab, and E the effective width over which the load is assumed to be distributed.

The allowable wheel load, ignoring impact, according to AASHO Specifications, would have been 9.5 kips at Bannockburn and 12.5 kips at Poplar Hill. The test results indicate no significant difference between the two and there was a minimum over-all load factor of 7.8 at Bannockburn and 5.6 at Poplar Hill.

It should be pointed out that a slab failure near an exterior stringer results in a loss of composite action for that stringer together with a loss of lateral support. The ultimate strength of a bridge deck would be substantially increased if the slab were to be made thicker between the exterior stringer and the first interior stringer. Consideration might also be given to providing concrete encasement for the web of the edge beam. (See Fig. 12).

Results of Tests of the Laboratory Bridge: The laboratory bridge was designed to carry a 15 ton traction engine with 10 tons on the rear wheels and 5 tons on the roller. The original deck was a 6 in. slab of reinforced concrete. Assuming the same load on the timber decks plus the dead load the stress produced in the stringers for an effective wheel load of S/4 would have been 12.5 ksi. The stress produced by an *H*-15 loading assuming the same distribution of load and making no allowance for impact would have been 14.9 ksi. With impact at 30%, the stress would have been 19.3 ksi.

No attempt was made to load the stringers beyond the yield point (assumed to be at 36,000 p.s.i. and each test was stopped before yielding occurred. The average wheel loads required to produce this stress on an interior stringer were:

a) with the deck laminations perpendicular to the stringers, 44.8 kips; and
b) with the deck laminations at an angle of 45° to the stringers, 40.6 kips.

The comparable theoretical wheel loads according to Hendry and Jaeger's theory were:

a) 46.5 kips; and
b) 38.0 kips.

The theoretical values of wheel load to produce a stress of 36,000 p.s.i. in the stringers correspond very closely to the experimentally obtained values.

It has been explained previously that a timber deck can only distribute a load laterally and cannot contribute any strength in the direction of the stringers. It would therefore be expected that the experimental and theoretical results would show close agreement since the only variable affecting the result is the ratio of the elasticity of the timber to that of the stringers. Hendry and Jaeger[8] point out that the result of a poor estimate for the value of the elasticity of the deck has only a small effect on the calculated distribution.

Load Distribution: The theoretical values of the bending moments and deflections have been calculated using the Hendry and Jaeger method. In these calculations the stringers were assumed to be simply supported and the stiffness of the timber laminations was found, by laboratory tests to be 125 x 10^6 lb. in.^{2}/ft. length. These theoretical values are compared with the experimentally obtained values of bending moment and deflections in Tables X and XI.

The results for both decks show an excellent agreement with the calculated values.

Comparing the bending moments on the basis of an empirical distribution factor similar to that given by the AASHO. Specifications we obtain, for the interior stringers, a wheel load fraction of S/5.7. In this instance the value of S is taken as the distance between adjacent stringers measured along the direction of the laminations. For a deck in which the laminations are at an angle of 45° to the stringers the value of S would be $\sqrt{2}$ times the perpendicular distance between the stringers.

Concentrated Load Applied Between Stringers: Two tests were carried out on the second deck with the wheel loads applied between stringers. Failure of the timber deck occurred at wheel loads of 50 kips and 48 kips. One of these failures is shown in Fig. 7.

Table X
Laboratory Bridge
Comparison of Experimental and Theoretical Mid-Span Bending Moments in Stringers

Wheel Load 20 Kips
Load Applied at Mid-Span

Stringer	*Exp. Bending Moment Kips Ft.* M_1	*Theo. Bending Moment Kips Ft.* M_2	M_1/M_2
	Cycle I (Load on Stringer A)		
A	53.4	48.4	1.10
B	8.0	10.8	0.74
C	0.0	1.7	—
	Cycle II (Load on Stringer B)		
A	5.4	10.8	0.50
B	34.2	31.7	1.08
C	12.6	13.4	0.95
D	0.0	1.5	—
	Cycle III (Load on Stringer C)		
A	0.0	0.0	—
B	11.5	13.9	0.83
C	34.5	31.7	1.09
D	34.5	12.9	0.89
E	0.0	1.5	—
	Cycle IV (Load on Stringer D)		
B	0.0	1.5	—
C	12.1	12.9	0.95
D	33.8	31.2	1.08
E	12.1	12.9	0.95
F	0.0	1.5	—
	Cycle VIII (Load on Stringer B)		
A	0.0	6.3	—
B	35.2	38.6	0.91
C	2.8	11.4	0.25
D	0.0	0.0	—
	Cycle IX (Load on Stringer C)		
A	0.0	0.0	—
B	0.6	10.8	0.05
C	37.7	37.1	1.02
D	3.2	11.4	0.28
E	0.0	0.0	—
	Cycle X (Load on Stringer D)		
B	0.0	0.0	—
C	4.3	10.4	0.41
D	41.6	37.1	1.12
E	4.3	10.4	0.41
F	0.0	0.0	—

The allowable wheel load according to the AASHO Specifications would have been 8.0 kips with no impact consideration. The minimum overall load factor (from the test results) would have been 6.0.

Conclusions

The following conclusions are based upon the results of a series of static tests. Caution must be used in applying these conclusions to structures subjected to repeated loads.

1. Bridge floors consisting of concrete slabs resting on I-beam stringers have considerable reserves of strength. They are capable of supporting large wheel loads without risk of either failure or excessive deflection.
2. A realistic estimate of the load distribution between stringers may be obtained by harmonic analysis assuming simply supported ends and the full section of the concrete slab to be effective.
3. The maximum fibre stresses in the stringers and their deflections are substantially reduced by composite action even when there is no adhesive bond between steel and concrete. The actual fibre stress may be estimated with reasonable accuracy on the basis of an assumed degree of composite action.
4. The ultimate resistance of the slab to concentrated loads is much greater than is indicated by conventional calculations. A 6 in. slab with a moderate amount of reinforcement will not fail until a wheel load of about 70 kips has been applied. The slab is weakest near to an exterior stringer. Failure of the slab may result in failure of the exterior stringer.
5. A bridge deck consisting of timber laminations supported by steel stringers can be accurately analysed by using harmonic analysis. In this instance there is no uncertainty as to the amount of composite action since this is zero. The ultimate resistance of the deck to concentrated loads is high for a 6 in. deck supported on closely spaced stringers. With a stringer spacing of less than 4 ft. the deck will not fail until a wheel load of about 40 kips has been applied.

Table XI
Laboratory Bridge
Comparison of Experimental and Theoretical Mid-Span Deflections in Stringers

Wheel Load 20 Kips
Load Applied at Mid-Span

Stringer	*Exp. Deflection Ins.* d_1	*Theo. Deflection Ins.* d_2	d_1/d_2
	Cycle I (Load on Stringer A)		
A	0.318	0.308	1.03
B	0.062	0.078	0.80
C	0.002	0.014	0.14
	Cycle II (Load on Stringer B)		
A	0.076	0.078	0.98
B	0.192	0.190	1.01
C	0.072	0.098	0.74
D	0.008	0.010	0 80
	Cycle III (Load on Stringer C)		
A	0.006	0.000	—
B	0.068	0.098	0.69
C	0.196	0.190	1.03
D	0.072	0.090	—
	Cycle IV (Load on Stringer D)		
B	0.004	0.010	0.40
C	0.072	0.090	0 80
D	0.180	0.186	0.97
E	0.072	0.090	0.80
F	0.004	0 010	0.40
	Cycle VIII (Load on Stringer B)		
A	0.046	0.046	1.00
B	0.240	0.238	1.01
C	0.044	0.080	0.55
D	0.000	0 000	—
	Cycle IX (Load on Stringer C)		
A	0.000	0.000	—
B	0.038	0.078	0.49
C	0.242	0.228	1.06
D	0.042	0.079	0.53
E	0.000	0.000	—
	Cycle X (Load on Stringer D)		
B	0.000	0.000	—
C	0.032	0.074	0.43
D	0.234	0.228	1.03
E	0.032	0.074	0.43
F	0.000	0.000	—

Acknowledgements

The studies reported in this paper were carried out at Queen's University, Kingston, in co-operation with the Ontario Department of Highways as part of the Ontario Joint Highway Research Program.

The field work was planned by Dr. D. T. Wright whilst at Queen's University and carried out under his direction by R. W. Cockfield and B. B. Hope. This report is based in large measure on the two M.Sc. theses submitted by Cockfield and Hope in April, 1959.

The field work was made possible by the assistance of many people. Mr. W. R. Schriever of the Division of Building Research of the National Research Council, gave much helpful advice. The laboratory tests were carried out by T. C. R. Joyce and P. Moran, graduate students in Civil Engineering. The experimental results were analysed by T. C. R. Joyce. Mr. A. M. Toye, Bridge Engineer of the Ontario Department of Highways, took a continuing interest in the project and made many helpful suggestions.

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Discussion

BACKWATER COMPUTATIONS FOR THE ST. LAWRENCE POWER PROJECT

Part A—Hydraulic Engineering Aspects of Computations

H. M. McFarlane,
Hydraulic Design Engineer, Ontario Hydro, Toronto

The Engineering Journal, February 1960, page 55.

Author's Reply to Discussion by J. A. Thomas, M.E.I.C.

At Ontario Hydro, backwater computations in river channels containing inconsistencies such as channel enlargements are carried out almost exclusively by means of Leach's Method. In all cases the velocity head at each backwater section or station is included in the solution, and the energy loss in a reach (including bend and expansion losses) is indicated by the slope of the energy gradient. Experience has shown that backwater computations made by means of Leach's Method are reliable, and in the case of the St. Lawrence Power Project the computed slopes were very close to the performance of the headpond reservoir.

The interpolation formulae were intended for use in interpolating only, and as such, gave reasonably satisfactory results. However, it would appear that they might be used at least as a guide if extrapolation were found necessary, although values of Mannings "*n*" beyond the selected range (0.020–0.050) are not normally used in open channel computations.

Fig. 2 in the paper gives the profile computed by the digital computer for the three assumed values of "*n*", and also includes the derived profile interpolated from the other three using the selected value of "*n*". The intention in the paper was to indicate that the interpolated profile based on the selected value of "*n*" indicated slightly higher loss than the profile computed manually using the same selected "*n*" value.

THE EVOLUTION AND APPLICATION OF LARGE SYNCHRONOUS AND INDUCTION MOTORS IN CANADA

G. W. Herzog, M.E.I.C.,
K. Z. Lukaszewicz,
Canadian General Electric Company, Peterborough.

The Engineering Journal, July 1960, page 51.

Discussion by A. J. Girdwood

The authors have presented an excellent summary of the evolution and state of the art of large synchronous and induction machines in general. However, I fail to find too much reference to specific Canadian developments.

Canada has hydraulic power development very comparable in total size to that in the United States. This has resulted in Canadian design engineers accumulating a great deal of experience in large alternating current generators, and making many original contributions to the art. This naturally spills over into the very similar synchronous motor art.

In the field of synchronous motors per se we have also had a very large market in paper mills, and this has made it possible for many original contributions to be made.

More specifically I think of development along the line of stator slot wedges which are designed to improve the flow of air and hence of cooling.

In addition I believe that original methods of constructing stator frames were developed.

In the field of staftless motors, i.e. motors designed so that the rotor mount on the shaft of the driven equipment, (usually air compressors), there have been — I believe — some original mounting methods developed.

Would the authors care to comment on the general subject of original Canadian development work?

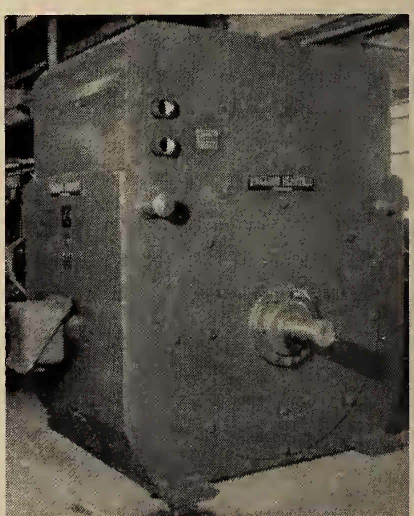
Discussion by John R. M. Szogyen, Jr.E.I.C.

I should like to congratulate Mr. Herzog and Mr. Lukaszewicz for their paper. It is an excellent presentation of Canadian Engineering achievement.

Making electric motors here in St. Catharines we have found, as the authors relate for their own experience, that the introduction of welded construction opened up many possibilities for the application and design of large motors. The freedom of shape which is possible with the welded construction is well illustrated by the authors. I should like to supplement this by my Fig. 1 showing a 1200 hp., 900 r.p.m., totally enclosed water-to-air cooled synchronous motor; this is representative of the predominantly rectangular appearance to which economy and functional design often leads with welded construction.

My Fig. 2 shows five 5000 hp., 275 r.p.m., 6600 volt, synchronous motors of the open type driving pulp grinders in a Canadian pulp mill. The welded construction of these large open motors allows a design that fully utilizes the laminated magnetic stator core to contribute towards the strength of the structure. My Fig. 3 shows the stator of a 4500 hp., 273 r.p.m., 6000 V, synchronous motor of the open type; this motor will drive a reciprocating compressor. It is one of six now being made at St. Catharines for export to Europe.

Fig. 1. 1200 hp., 900 r.p.m. totally enclosed water - air - cooled synchronous motor.



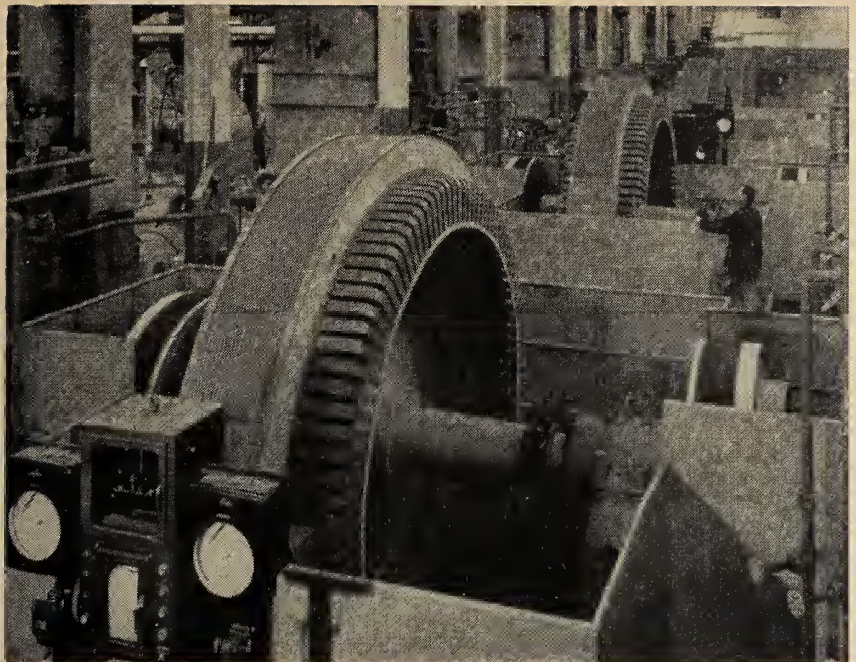


Fig. 2. 5,000 hp., 275 r.p.m., pulp grinder motors installed at Great Lakes Paper.

The authors mention a trend towards applying open-dripproof motors outdoors taking advantage of improved insulation systems. I should like to ask the authors if this trend is not mainly in the southern parts of the United States with climates, and particularly winters, much more temperate than in Canada. It is thought that the Canadian winter with its large quantities of snow necessitates protection of the inner working parts of the motor even though the coil insulation may withstand exposure to moisture. I should like to ask the authors for their opinion on this difference in enclosure requirements governed by climatic differences.

Author's reply

The authors thank those who presented a discussion on the paper. We appreciate your interest.

Replying to Mr. Szogyen's question on the use of enclosures for outdoor operation; certainly sealed insulation systems are not a panacea for outdoor operation in all climates. The choice of enclosure must be governed by service conditions such that snow and dirt do not clog the ventilation passages or adversely affect the motor's operation. Open dripproof motors are replacing totally-enclosed motors to some extent in the pulp and paper industry, rubber industry, and in the steel industry for certain applications.

We appreciate Mr. Girdwood's discussion because of his contribution to the art of designing rotating machines and because of our former association with him. We confirm that the improvements he mentioned were made and also that he contributed to them.

The authors, in writing the paper, had not intended to describe many of the specific details of construction or lay claim to specific developments because it was thought that this information would not be of general interest.

Motors produced in Peterborough are designed in Canada with full knowledge of Canadian requirements and conditions. Development is a continuing process. Many contributions were made to the art over the years both in performance and construction of synchronous and induction machines. Ventilation improvements mentioned in the paper, improved rotor construction, top exhaust frames, the application of epoxy resins to rotor coils, are Canadian developments. Some other developments not mentioned, and which have occurred, include:

Asymmetrical pole spacing to prevent locking;

Part winding starting, now largely abandoned;

Double end rings on amortisseur windings;

Single end ventilation;

Split pole stator windings.

Considerable effort has been devoted recently to the application of the digital computer to the design of rotating machines. Part of this work was reported to the AIEE a year ago in Paper #59-122.

THE ECONOMICS OF AN INDUSTRIAL GAS TURBINE

D. Panar, M.E.I.C.
Assoc. Professor, Mechanical Engineering, University of Alberta, Edmonton
The Engineering Journal, August 1960, p. 59

Discussion by R. E. Chant, M.E.I.C.

The installation described in this paper is not a common application of a gas turbine. The paper therefore describes a problem unfamiliar to the engineer, perhaps too unfamiliar. The

(Continued on page 140)

Fig. 3. 4500 hp., 0.8 pf., 272 r.p.m. 6000/3/50 engine type synchronous motor (showing stator being wound).

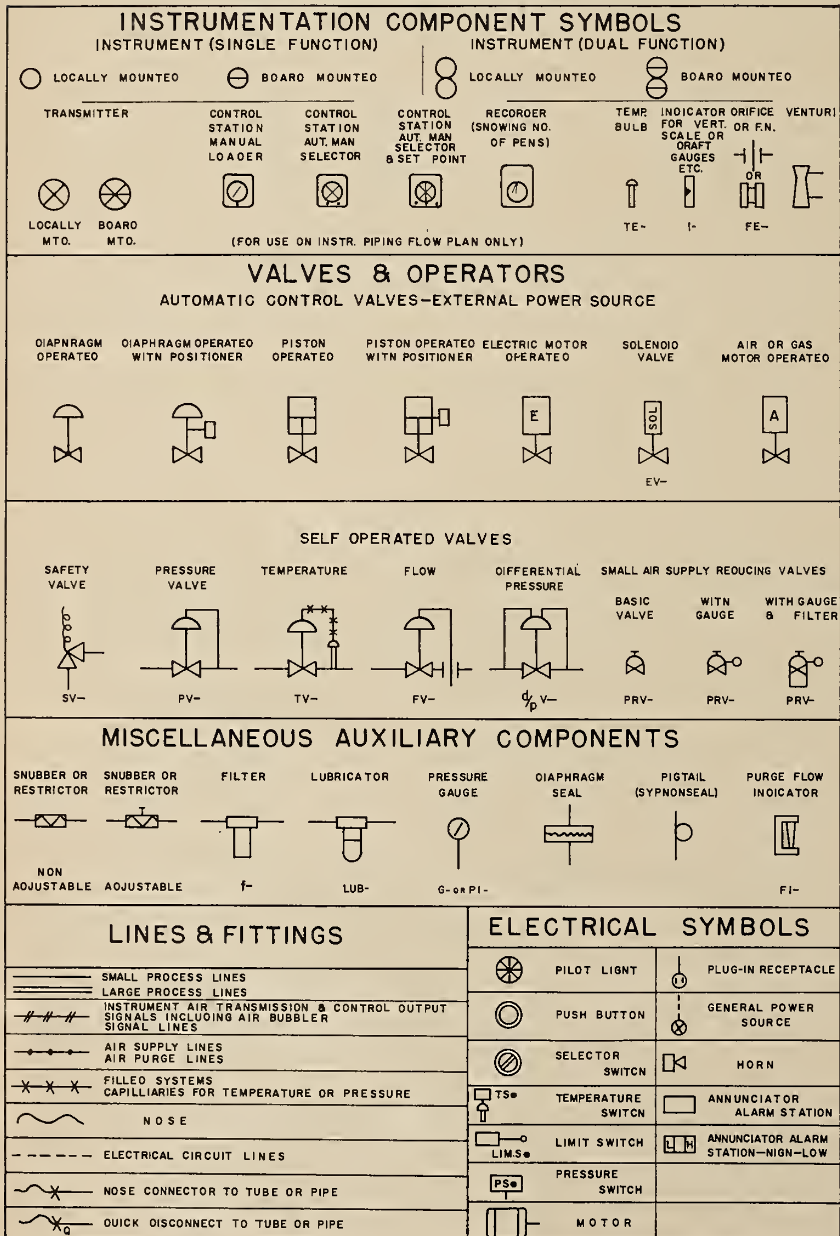
Automation and Control Engineering in Canada

INSTRUMENTATION CODING AND SYMBOLS

J. T. Dykes, JR.E.I.C.

Instrument Engineer, Central Engineering Department,
Dominion Tar and Chemical Company Limited, and Howard Smith Paper Mills Limited, Montreal.

Fig. 1. Instrumentation Symbols.



THE system of coding presented here covers the identification of instrument component functions through the use of a combination of letters and abbreviations; the specific identification of components in control loops by means of a numbering system, and a list of simple pictorial symbols for illustration purposes on flow plans and other drawings. The terminology is based upon standards proposed by the Instrument Society of America (Recommended Practice RPS-1), on an extension of these standards by the Canadian Pulp and Paper Association (Technical Section data sheet S-1) and on methods used within the Dominion Tar and Chemical organization. It is intended that this system will provide a time and space saving method of instrument identification which can be readily interpreted. In particular these coding methods should be used to identify instrument equipment on specification sheets, correspondence, purchasing forms and maintenance records; flow plans, piping and layout drawings; and also as a basis of tagging the actual equipment and interconnecting lines.

Function Identification

The function identification of major instrument components consists of letters or abbreviation used in combination as shown in Table 1. and 1A. The purpose is to identify the component in terms of the process variable and what function the equipment performs. Particular reference is made to primary elements; measuring, controlling, transmitting and alarm devices; and also whether they provide a recording, indicating or integrating function.

The use of the letters or their com-

TABLE 1. FUNCTION IDENTIFICATION FOR BASIC PROCESS VARIABLES

FIRST LETTER		SECOND AND THIRD LETTER (TYPE OF DEVICE)																					
			MEASURING DEVICES				TRANSMITTING DEVICES [7]			CONTROLLING DEVICES										CONTROL STATIONS			
													Valves and Operators				Switches [5]						
First Letter [1]	Process Variables	Primary Elements	Indicating	Recording	Totalizing or Integrating [6]	Glass Devices for Observation Only	Blind	Indicating	Recording	Blind	Indicating	Recording	Self-Actuated Valves	Safety Valves	Externally Powered Control Valve	Externally Powered Operator	Blind	Indicating	Recording	Blind	Indicating	Recording	Alarm Devices [9]
		—E	—I	—R	—Q	—G	—T	—IT	—RT	—C	—IC	—RC	—CV	—SV	—V	—P	—Sw	—ISw	—RSw	—K	—IK	—RK	—A
A	Analysis, Concentration	AE	AI	AR	AQ		AT	AIT	ART	AC	AIC	ARC			AV	AP	ASw	AISw	ARSw	AK	AIK	ARK	AA
C	Conductivity	CE	CI	CR			CT	CIT	CRT	CC	CIC	CRC			CV	CP	CSw	CISw	CRSw	CK	CIK	CRK	CA
D	Density	DE	DI	DR			DT	DIT	DRT	DC	DIC	DRC			DV	DP	DSw	DISw	DRSw	DK	DIK	DRK	DA
E	Electric General (Power, Voltage, Current, etc.)		EI	ER	EQ		ET	EIT	ERT	EC	EIC	ERC	ECV		EV[3]	EP	ESw	EISw	ERSw	EK	EIK	ER	EA
F	Flow	FE	FI	FR	FQ	FG	FT	FIT	FRT	FC	FIC	FRC	FCV		FV	FP	FSw	FISw	FRSw	FK	FIK	FRK	FA
H	Hand (Remote Operated Valves, Manual Loaders, etc.)		HI	HR						HC[2]	HIC[2]	HRC[2]			HV[4]	HP[4]							
K	Combined (Multifunction Recorders, Indicators and Alarm Annunciators)		KI	KR	KN		KT	KIT	KRT	KC	KIC	KRC	KCV	KSU						KK	KIK	KRK	KA
L	Level, Altitude, Height	LE	LI	LR		LG	LT	LIT	LRT	LC	LIC	LRC	LCV		LV	LP	LSw	LISw	LRSw	LK	LIK	LRK	LA
M	Moisture or Humidity	ME	MI	MR			MT	MIT	MRT	MC	MIC	MRC			MV	MP	MSw	MISw	MRSw	MK	MIK	MRK	MA
P	Pressure or Vacuum	PE	PI	PR			PT	PIT	PRT	PC	PIC	PRC	PCV	PSV	PV	PP	PSw	PISw	PRSw	PK	PIK	PRK	PA
pH	pH (Hydrogen Ion Concentration)	pHE	pHI	pHR			pHT	pHIT	pHRT	pHC	pHIC	pHRC			pHV	pHP	pHSw	pHISw	pHRSw	pHK	pHIK	pHRK	pHA
S	Speed		SI	SR	SQ		ST	SIT	SRT	SC	SIC	SRC	SCV	SSV	SV	SP	SSw	SISw	SRSw	SK	SIK	SRK	SA
T	Temperature	TE[8]	TI	TR			TT	TIT	TRT	TC	TIC	TRC	TCV	TSV	TV	TP	TSw	TISw	TRSw	TK	TIK	TRK	TA
V	Viscosity	VE	VI	VR		VG	VT	VIT	VRT	VC	VIC	VRC			VV	VP	VSw	VISw	VRSw	VK	VIK	VRK	VA
W	Weight, Load, Force	WE	WI	WR	WQ		WT	WIT	WRT	WC	WIC	WRC	WCV		WV	WP	WSw	WISw	WRSw	WK	WIK	WRK	WA

NOTES:
1. Lower case letters—r, d and t may be used after the first letter to distinguish ratio, difference and time respectively.
2. Used to denote hand operated pilot valves used for remote operation.
3. Applied to valves operated from electrical power measurements and in general to solenoid operated auxiliary valves.
4. Remote operated valves not associated directly with the control of a single process variable.
5. Generally applied to contacts used for alarms or interlocks ("S" may be used as an alternative to "Sw").
6. Q may be used as third letter with I and R where indicating and recording functions also exist.
7. Transducers are further identified by Tx.
8. TW is used to indicate a protective well, while TE indicates a thermal element.
9. Alarm devices refer to actual alarm components, not the switch contacts. Visual or audible signals may be indicated by "L" and "B".

TABLE 1A. FUNCTION IDENTIFICATION FOR SPECIAL PROCESS VARIABLES

Note: This table includes first letter abbreviations to be used for specific applications. Second letter combinations would be in accordance with Table 1. Measurements other than these require full spelling.

Br	Break detections	**Har**	Hardness	**Sm**	Smoothness-surface finish, etc.
Cal	Caliper or thickness	**Lgth**	Length	**SO_2**	Sulphur Dioxide concentration
CO_2	Carbon Dioxide concentration	**O_2**	Oxygen concentration	**Sd**	Draw Speed (speed difference)
Cs	Consistency (% solids)	**Orp**	Oxydation-Reduction Potential	**Th**	Thickness
Fl	Flame detectors	**Pos**	Position, limit, motion	**Tor**	Torque
Free	Freeness (Pulp)	**Prod**	Production, operation	**Vib**	Vibration

binations should be based on the following instructions:

(a) All identifying letters are written in UPPER CASE except for special process variable abbreviations and the optional use of "d", "r" and "t" as per footnotes of Table 1.

(b) It is suggested that for purposes of brevity that the number of identifying terms should not exceed three.

(c) A letter shall have only one definition or significance in its use as a "first' letter in any combination, to define the process variable.

(d) A letter shall have only one definition or significance when used as either the "second" or the "third" letter in a combination, to define the type of device.

(e) It is particularly important in writing the combinations of letters to adhere to the sequence of arrangement shown by Table 1.

(f) No hyphens shall be used between letters or combinations of letters.

Table 1. is a listing of basic function identification letters considered as a general standard. Table 1A is a list of suggested forms to be used in more specialized applications such as consistency, thickness, length and position measurements.

Table 2. is a list of code letters used to describe auxiliary equipment. This is a classification that has not been covered by formal standards. It is presented here to show that a coding problem exists and to provide one solution for coding this group of minor components. This equipment is further identified by either loop numbers as described in the following section or by a consecutive numbering system for such items as filters and reducing valves.

TABLE 3.
INSTRUMENT CODING ZONE & SECTION NUMBERS
Howard Smith Paper Mills Ltd., Cornwall.

Zone 0—Miscellaneous
Equipment general to all areas

Zone 1—Pulp Mill Misc:
0—99 Miscellaneous
100—199—Wood Handling
200—299—Pulp Slushing
300—399—No. 1 Pulp Machine

Zone 2—Soda & Kraft Pulping
0—99—Miscellaneous
100—199—Washing & Screening
200—299—Digesters
300—399—Hot Water Recovery

Zone 3—Bleaching
0—99—Miscellaneous
100—199—Kraft
200—299—Soda
300—399—Sulphite

Zone 4—Liquor Recovery
0—99—Miscellaneous
100—199—Evaporators
200—299—#9 Recovery

Zone 5—Sulphite Mill
0—99—Miscellaneous
100—199—Acid Making
200—299—Digesters
300—399—Washers & Screens

Zone 6—Stock Preparation
0—99—Miscellaneous
100—199—Storage
200—300—Starch Supply

Zone 7—Paper Machine
0—99—Miscellaneous
100—199—No. 1 Machine
200—299—No. 2 Machine
300—399—No. 3 Machine
400—499—No. 4 Machine
500—599—No. 5 Machine
600—699—No. 6 Machine

Zone 8—Steam Plant
0—99—Miscellaneous
100—199—No. 10 Boiler
200—299—No. 11 Boiler

Zone 9—Chemicals and Byproducts
0—99—Miscellaneous
100—199—Bleach & Chlorine
200—299—Chlorine Dioxide
300—399—Vanillin

Zone 10—Research

Zone 11—Converting and Finishing.

Circuit or Loop identification

Instrument equipment has now been identified in terms of a process variable and in regard to its particular function. The next step in the complete coding of the instrument is to identify it in terms of the particular process application—commonly called the control loop or circuit. The rules and instructions for applying the loop identification are as follows:

1) Each instrument circuit or application should have one number assigned to it which should not be used on any other circuit or application.

2) When used in written work the number should be placed after the letters and separated from them by a hyphen. For example temperature recording controller, circuit No. 1 is written TRC-1.

3) All components in any circuit should have the same number; duplicate components in one circuit are identified thus: PI-1a, PI-1b, PI-1c.

4) For combination instruments that measure more than one variable, or that provide more than one function, each portion of the combination would have its own identification. However, the multifunction component itself is assigned a separate loop number and identified as to function by the letter "K". For example, a combination recorder for flow and pressure would have pens identified PR-1 and PR-5, but the entire recorder would be KR-6.

5) When accessories such as valve positioners, air sets, switches, relays, etc., require identification they should be assigned the same identification number as the other components in their circuit, e.g. solenoid valve EV-20.

The establishment of a loop numbering system in a large plant is not simply a matter of placing all known applications in numerical order. Rather, it is a complex problem which should satisfy the following conditions:

1. Numbers should be kept as short as possible.
2. Loop numbers should, where pos-

TABLE 2.
MISCELLANEOUS CODE LETTERS

AP—Air Purge.
B—Bell or Audible Alarm.
BIP—Black Iron Pipe.
CR—Electric Control Relay.
EV—Solenoid Valve. (2)
f—Filter. (3)
G—Instrument Air Gauge and miscellaneous process gauges of relatively little importance. (2) or (3)
GP—Gas Purge.
H—Hose.
L—Pilot Light. (2)
Pb—Brass Pipe.
Pos—Positioner. (2)
Ps—Steel Pipe.
Pss—Stainless Steel Pipe.
Pp—Plastic.
Q—Quick Connect Coupling.
R—Relay — booster, etc. (2)
S—Air or electric supply.
SP—Steam Purge.
Sw—Switch—Manually operated. Electric.
Tc—Copper Tubing.
Tp—Plastic Tubing.
Ts—Steel Tubing.
Tss—Stainless Tubing.
TW—Temperature Element Well. (2)
V—Hand Valves — Transfer Switches — Needle Valves — Snubbers, Restrictors, (2) or (3)
VC—Volume Chamber. (2)
WP—Water Purge.

Note:—
(1.) Items to be further identified according to process variable Table 1.
(2.) Items may be further identified according to loop numbers.
(3.) Identical items coded with same number.

sible, follow the sequence of the process.
3. Different processes should have a separate numbering sequence.
4. The system must be flexible in providing for additions to processes and for general plant expansion.
5. Where possible similar processes in separate plants should have the same numerical identification.

It is suggested that the plant be divided into process zones having similar functions. These zones may be further subdivided into particular processes. Geographical zones are generally not recommended. An example of a typical paper mill zoning system is shown in Table 3. This is based on the system used at Howard Smith Paper Mills, Limited, Cornwall, Ontario.

With reference to Table 3 zone O includes miscellaneous equipment and similarly section O of each zone includes equipment common to all sections. If we consider the steam flow transmitter for No. 6 paper machine, the functional identification would be FT—and the loop identification would be 7-621. The complete identification for this equipment would be FT-7-621. In the delegation of numbers, spare numbers are left to provide for additions to the process. In the event that more than 100 control loops are required for a process section, the section number is considered as the first number only. In the case of No. 6 paper machine typical numbers would be 7-699, 7-6100, 7-6101 and so on. This method keeps the numbers small yet retains flexibility.

Symbols

Instrument symbols are used to provide a quick identification of the function and in some cases the location of components. They are used on process flow plans and instrument piping flow plans. In the latter case it is often desirable to draw in a more descriptive way, such items as

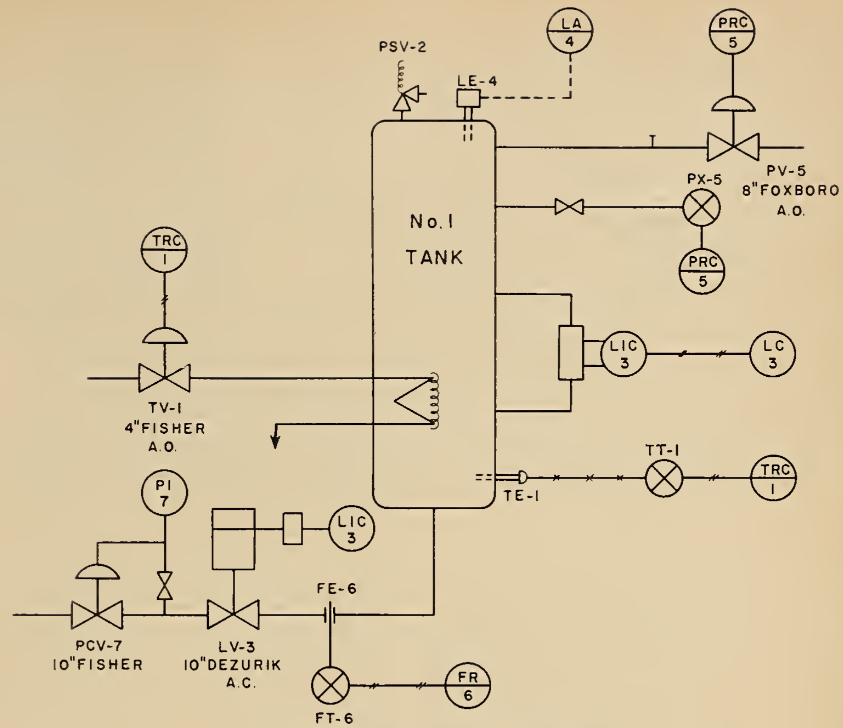


Fig. 2. Typical Process Flow Plan.

recorders, control stations and alarm annunciator stations. In special cases, a brief explanatory notation may be added alongside a symbol to clarify its function or to show pertinent design data. A few such notes are easier to apply and use than a great variety of more complicated symbols.

The symbols shown in Fig. 1 are based on recommended standards by both the ISA and CPPA. These have been extended to include such items as self operated valves, valve positioners, auxiliary equipment and a more detailed identification of control stations and recorders.

Fig. 2 shows an example of how these symbols are used on a process flow diagram. In general only the primary elements, transmitters and final control equipment, together with references to recording or control instruments, are shown on the process flow sheet. On the other hand, the detailed instrument flow diagram must show all instrument components, lines and connections. In this case it is desirable to employ component symbols which are more descriptive, especially in the case of recorders and control stations.

In the establishment of a standard coding system it must be understood that in the interest of simplicity it is not possible to cover every possible variance—nor is it possible to satisfy the opinions of all the experts in regard to terminology. At the same time it is in the general interest of all concerned to standardize at least on the majority of function coding, on the basic principles of loop identification and the graphic symbols for major components and connecting lines. It is hoped that the presentation of this data will assist in the acceptance of a standard method of instrument identification.

75th Annual General and Professional Meeting

May 31-June 2, 1961

Vancouver, British Columbia

Canadian Developments

The massive Place Ville Marie Project in Montreal, featuring a 42-storey Cruciform Building, now is about 18 months from completion. The development, excluding the Cathcart Street Building and the Mansfield Street Building, will have a floor area of more than 3 million square feet. By early autumn about 15 tons of structural steel had been erected and an additional 10 tons was scheduled for erection by early 1961. Approximately 200,000 cubic yards of rock and earth had been excavated and about 50 tons of concrete had been poured.

As the steel work of the Ville Marie Project is etched higher against Montreal's skyline, the value of extensive preplanning becomes increasingly apparent. A. P. V. Bennett, project engineer for the general contractors, The Foundation Company of Canada Limited, says that in the pre-planning of such a large job the temporary services become greatly important. These services include passenger elevator service, plumbing and drainage, heating, light and power, communication, material towers, and the extremely important safety program.

Permanent hoistways are to be used to provide temporary passenger elevator service. These temporary elevators are planned to be in service within four weeks of the completion of the structural steel erection at the various elevator machine room floors. The first instance is the second floor. Initially, elevator stops will be so provided that workers will have a maximum walk of three floors. Longer walks will be required until four elevator banks are in operation, with stops up to the 41st floor. It is planned that in all cases the permanent passenger elevator machinery will be used for temporary service. However, temporary equipment will be provided for the second floor stop.

The temporary plumbing and drainage service includes temporary water lines, sanitary facilities and fire protection. A temporary 4 in. riser will be installed in sections in the core of the Cruciform Building as soon as the metal deck is placed. At the same time a permanent drain stack will be erected to connections which will be made from various services in the building. Fire hose stations will be connected by branch lines from the temporary riser at each floor, and these will remain activated until replaced by the permanent fire protection installation. Where water is not available portable hand-type fire extinguishers will be provided adjacent to the actual work area. On each floor there also will be two 45 gal. drums with a water connection to the riser. This connection will be discharging water continuously into the drums and a suitable overflow pipe will be provided at the top of the drums to connect back into the drain stack.

For sanitary facilities there will be two washrooms at the Plaza level and adjacent to the wet columns and located at every fifth floor there will be additional washrooms in one of the wings. When permanent washrooms are finished in the core of the building the temporary toilets will be transferred and connected in these washrooms. They will remain in service until the permanent washrooms are ready.

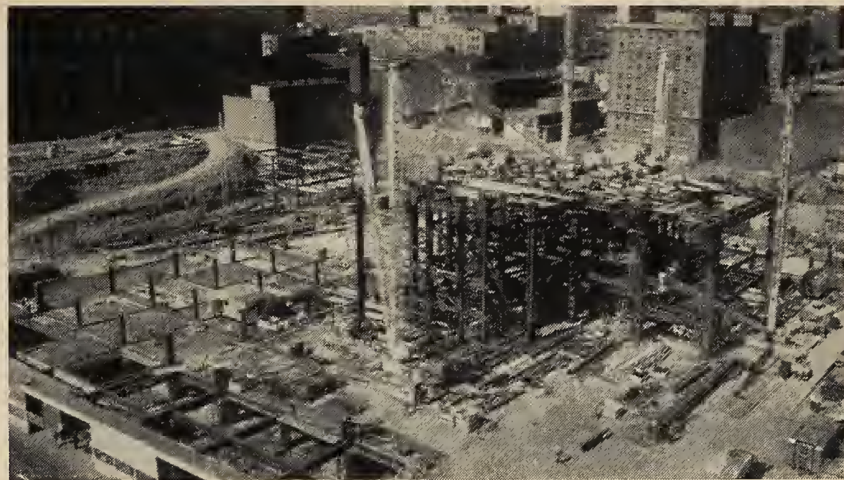
There is no provision for a central steam generating plant on this project. Steam requirements will be provided by the Canadian National Railways from its generating plant. When work permits, a high-pressure steam riser will be erected in stages up to the lower mechanical floor. For the lower 20 floors two permanent secondary water supply risers will be pushed up as soon as possible behind the structural steel. These will be used as temporary steam supply risers. Two permanent re-heat supply risers will be used as temporary condensate return risers. A temporary piping system will be provided at the lower mechanical floor to reduce the high-pressure steam to serve requirements. Four unit heaters will be installed at each floor. The aim in heating the building is to keep to a minimum the temporary requirements and heating, and to put the permanent heating installation into operation as soon as possible. The unit heaters from the lower 20 floors are expected to be re-used in the upper 20 floors during the 1960-61 heating season.

Temporary light and power has been planned in a manner similar to the other services. To be provided for in this instance are general lighting, fire station lighting, special temporary lighting in storage areas, hoisting areas, hoistway

Lower Level Construction

entrances, exits and temporary equipment, passenger elevator service and material tower hoists. A 1,000 kva. temporary sub-station serving the power requirements now is being augmented by a 1,500 kva. unit. Permanent transformer equipment in the sub-station will be put into operation as soon as possible as it is expected that the material hoists will require the full output from the sub-station when they all are working together. Temporary lighting is based on one-quarter watt per square foot.

Three double material towers have been provided for the service of the building during the construction period. Users of the towers will be required to schedule their deliveries sufficiently in advance to avoid congestion at the tower accesses. A closed-circuit telephone service will aid control of hoisting operations. A public address system will provide freedom of communication at all times by personnel in the building.



View Looking North

The safety program is under the direction of Murray Miner who has had field experience and extensive training. Prior to his appointment as Safety Co-Ordinator, Mr. Miner received a course on the Lateiner Method of Accident Control given by the Construction Safety Association of Ontario. Key to the success of the Safety Program is the instruction of all foremen in the application of accident control methods. All foremen, including those of sub-contractors, are given a course of instruction by Mr. Miner, after which they are given a written test. The result of having a foreman with a good knowledge of accident control means that the workers are constantly exposed to a safety-conscious person who can instruct them in safe working habits.

Because of this program the Ville Marie Project has experienced extremely favorable rates of accident frequency and severity. Figures compiled to Sept. 15 showed approximately 1,025,000 man hours had been worked. The accident frequency rate was 45.83 and the severity rate was 963. According to the latest figures available for general contractors, the national average accident frequency rate was 52.9 and the severity rate was 2,583. EIC

International News

Russia's achievements in the field of hydraulic generation and EHV generation are outstanding, concluded a delegation from Canadian electric utilities which visited power installations and industrial centres in European Russia and Siberia in May. Members of the group felt Russian achievements in thermal generation and atomic power generation were not particularly impressive. Short and long-range plans, co-ordinated with the U.S.S.R.'s total national objective, were believed by the group to provide the necessary priority and purpose for such large-scale effort.

Considering their present status and post-war performance it appeared their general objective will be achieved. The delegates also concluded that it would be mutually beneficial to continue technical liason between electric and utility organizations in Canada and Russia and that early consideration should be given to means through which this co-ordination could best be achieved.

The priority in Russia is being placed on the construction of fossil fuel fired thermal stations rather than hydraulic stations. In spite of this priority there was no evidence that hydro plants under construction which were visited were not being pushed to completion at a rapid pace.

Members of the delegation were: H. P. Cadario, Assistant Director of Engineering, Ontario Hydro; J. S. Duncan, Chairman, Ontario Hydro, Toronto; H. M. Ellis, Chief, Electrical Research, International Power and Engr., Consultants, Vancouver; A. E. Grauer, President, British Columbia Electric Company Limited, Vancouver; J. L. Gray, M.E.I.C., President, Atomic Energy of Canada Limited, Ottawa; R. E. Grout, M.E.I.C., Vice President, Shawinigan Engineering Company, Montreal; A. W. Howard, M.E.I.C., General Manager, Calgary Power Limited, Calgary; F. L. Lawton, M.E.I.C., Vice President and Chief Engineer, Power Division, Aluminium Laboratories, Montreal; H. A. Smith, Assistant General Manager, Engineering, Ontario Hydro, Toronto; A. W. Southam, Managing Director, British Newfoundland Corporation Limited, Montreal; and D. M. Stephens, M.E.I.C., Chairman and General Manager, Manitoba Hydro-Electric Board, Winnipeg.

A report of the visit was prepared by Mr. Cadario and Mr. Smith. It was revised to incorporate changes and additions recommended by other members of the delegation. This article was prepared from the report.

Development of the power system has two guides—a 20-year general plan and a more specific seven-year plan due to end in 1965. It was stated repeatedly that increasing emphasis was being given thermal plants because they would provide more capacity in a given time than hydraulic plants. The general approach is to concentrate on large-capacity plants, up to 6,000 Mw. hydraulic and 2,400 Mw. thermal. This would incorporate units up to 500 Mw. hydraulic and 300 Mw. single-shaft and possibly 800 Mw. two-shaft thermal units. Accompanying this is an extensive program for transmission lines. The seven-year plan calls for 6,600 miles of 500 kv. line, 4,000 miles of 300 kv. line, 19,000 miles of 200 kv. lines and 100,000 of lower voltage lines down to 35 kv. The program also incorporates 7,000 new substations.

The following table indicates the development of installed capacity in megawatts in the Soviet Union from 1913 until 1959, and the 1965 target.

Year	*Thermal*	*Hydro*	*Total*
1913	1,082	16	1,098
1925	1,371	26	1,397
1935	6,027	896	6,923
1945	9,872	1,252	11,124
1950	16,396	3,218	19,614
1955	31,250	5,996	37,246
1957	38,356	10,040	48,396
1959	46,520	12,620	59,140
1965	90,400	22,600	113,000

Two aspects of the power planning system in the U.S.S.R. are fundamentally different from the approach generally used in other countries. Firstly, the overall plan for the power system is only a component of a much broader plan for regional and national industrial development. Secondly, it would appear that the broader industrial plan has one primary objective—to attain maximum capacity in the shortest possible time.

Hydro-Electric Stations

Only about 3% of Russia's vast hydroelectric potential has been developed. These resources are scattered, with the largest potential in the northern and eastern parts of Siberia. Large rivers provide for extremely large plant installations such as the 4,500 Mw. Bratsk project on the Angara River. The Bratsk development is now under construction. Other projects are estimated as high as 20,000 Mw. Geological conditions peculiar to European Russia increased problems associated with large plants.

Hydraulic plants on the Volga and other rivers in the area are located mainly on non-rock foundations. Northeastern plants, as Bratsk and Krasnoyarsk, are located on rock. What appear to be satisfactory installations at Kuibyshev and Stalingrad were provided following comprehensive geological investigations, and unusual designs of the powerhouse and spillway for differential settlement. These plants, which have the greatest peak capacity in the world, have experienced considerable settlement without unsatisfactory performance.

Certain plants, including the Kuibyshev and Stalingrad, employ submerged spillways as part of the powerhouse. Russian engineers said this design reduced concrete needs by 10% to 12% and provided increased turbine output due to tailwater suppression, particularly during high-flow periods. Both plants have trash racks on structures separate from the powerhouse. This unusual design was adopted to reduce loss of head at the units due to large amounts of foreign material in the Volga. Methods of removing this at the trash racks apparently were inadequate. Russian engineers indicated this design would not be repeated.

Powerhouse and spillway construction was a mixture of precast and poured concrete. Construction methods, based on maximum mechanization, appeared very efficient. The delegation was told that by 1965 precast concrete will be used for 90% of hydraulic plant construction. Design and manufacture of large hydro turbines and generators are good. They are operating 115 Mw. Kaplan units at Stalingrad and at one Kuibyshev station and are producing 225 Mw. Francis type units for Bratsk. They have designed 500 Mw. units for the Krasnoyarsk station now under construction.

Thermal Power Stations

Post-War operating plants have a maximum capacity of 600,000 kw., with most unit sizes 100 Mw. to 150 Mw. Factory production facilities were geared to produce boilers and turbo-generators of this size with moderate steam conditions.

Factories visited at Kharkov and Leningrad had 200 Mw. and 300 Mw. units in production. The 200 Mw. units were in mass production while the 300 Mw. units were the first in this size. Engineers were making designs for units of 500 Mw., 600 Mw., and 800 Mw. It would appear they intend to expand size and steam conditions rapidly. They intend to standardize certain sizes and mass produce them.

Observed at Leningrad Metal Works were completed 165 mva. turbo-generators with water-cooled stators, although most of their present designs, including the 200 Mw. units, are hydrogen cooled. Production facilities and products, including finished units, appeared good and of high standard.

The use of precast concrete and prestressed concrete at the thermal power stations was most noticeable. Little structural steel was used. To reduce construction time the Russians intend to do more field erection of boilers, including the fabrication of sections in the field.

Nuclear Plants

The nuclear program plays a minor role in the seven-year plan. The general view is that nuclear plants will not compete economically for some time, and that safety and reliability charasteristics are not well known. Neither do they consider they have a good reliable fuel. When such a fuel is developed the program will be accelerated. The present effort is directed primarily toward obtaining experience by building and operating several types of plant. EIC

75th Annual General

and Professional Meeting

Vancouver, B.C.

May 31 - June 2, 1961

Month to Month

Two significant international conferences concerning engineering were held in Montreal early in October. Attending were delegates from Canada, the United States, in addition to guests from France, Mexico, and Russia. The Mexicans were members of a technical educational mission who chose Montreal as the first stop on an extensive tour of Canadian and American university cities. The conferences were the 28th Annual Meeting of the Engineers' Council for Professional Development, Oct. 3-4, and the Fourth Biennial Engineering Education Conference, Oct. 5-6.

The visit of eight Mexican engineers and scientists was sponsored jointly by UNESCO and the Bank of Mexico. Its purpose was the observation of teaching methods and possible applications in industry. The Institute, at the request of the Department of Trade and Commerce, arranged the 10-day Montreal segment, which began Oct. 3. The Mission was headed by Alberto Bremauntz, Representative of the Bank of Mexico, Productivity Office, Industrial Research Department. Others were: Jose Acevedo, Director of the Faculty of Chemistry of the University of Guanajuato; Guillermo F. Davalos, Director of the Faculty of Chemistry of the University of Nuevo Leon; Ruben Ortiz, Director of the Faculty of Chemistry of the Autonomous University of San Luis Potosi; Alfredo Ortega, Director of the Faculty of Chemistry of the University of Yucatan; Antonio Elizondo, Head of the Department of Electrical Engineering at the Institute of Technology and Higher Studies of Monterrey; Jose Raigosa, Secretary of the Faculty of Engineering at the Autonomous University of Guadalajara; and Abel J. Navarro, Advisor on Industrial Research, National University of Mexico. Senora Acevedo accompanied her husband.

A tight working schedule had been arranged for the Mexican group and it entered into the activities enthusiastically. They arrived by air from Mexico City Oct. 3. Dean D. L. Mordell of McGill's Engineering Faculty was host at a luncheon several hours after their arrival. They toured McGill that afternoon and the following day, and attended the E.C.P.D. banquet on the evening of Oct 3. The group entered fully into the activities of the ASME-EIC Engineering Education Conference Oct. 5-6.

Mr. Dick and Senor Bremauntz take notes during University of Sherbrooke tour.

On the Friday of their first week they travelled by train to Sherbrooke. A thorough inspection of the University of Sherbrooke's new engineering and science facilities was arranged through the courtesy and co-operation of Rector Msgr. Irenée Pinard, Gaétan Côte, President of the Advisory Committee of the Science Faculty, Jean-Paul Champagne, Secretary of the Science Faculty and Head of the Electrical Division, and Abbé Sirois, General Secretary of the University.

Following a lunch at which Institute President George McK. Dick was host, the group toured the Sherbrooke plant of Canadian Ingersoll-Rand Co., Limited. They spent Thanksgiving weekend at a Laurentien resort during which they held extensive seminars on the Canadian aspects of their project. On Tuesday they were guests of Dr. H. Gaudefroy, Director of l'Ecole Polytechnique for a tour of the school. The following day the members visited industrial plants in Montreal.

The final item in this segment of their tour was a guided visit to the St. Lawrence Seaway, aided by John Akin, Chief Information Officer of the Seaway Authority. This tour began at the St. Lambert locks, where they saw the *Red Wing*—the largest vessel capable of using the facilities—lock down. Particularly impressive to the visitors was the Beauharnois power station which develops approximately the same amount of power as is generated by all of Mexico's hydro-electric facilities. The tour ended at Ontario Hydro's facilities near Cornwall, after which the group continued by bus to Ottawa where visits to the National Research Council and the University of Ottawa were scheduled. They left Canada by air for Chicago Oct. 15.

E.C.P.D.

The Council, composed of seven American societies and institutes and the E.I.C., is concerned largely with standards of engineering education and with accreditation of engineering schools. The United States bodies which participate are: American Society of Civil Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers; The American Society of Mechanical Engineers; American Institute of Electrical Engineers; The American Society for Engineering Education; American Institute of Chemical Engineers; and the National Council of State Boards of Engineering Examiners.

Reports of internal committees consumed most of the opening day's sessions, which were augmented by luncheon and banquet meetings. Canada's interest in this field does not yet extend to the accreditation of engineering schools, and this was referred to in the banquet address by Col. L. F. Grant of Kingston.

"This is a problem we have not yet faced in Canada," Col. Grant said. "We now have only 11 degree-granting engineering schools, but soon we will have 20. We have talked a lot about it, and have watched E.C.P.D.'s program in the United States with great interest. Their methods will be of great help to us."

Col. Grant is a past president of the E.C.P.D. and a past president of the E.I.C.

He touched briefly on the objectives of E.C.P.D. and said he hopes for continuing firm discussion on a contentious point in engineering education — the proper balance between theory and practice.

Alan Jarvis, editor of *Canadian Art* and a former director of the National Gallery in Ottawa, addressed the luncheon meeting.

Much construction, particularly in the post-war period, has been carried out without taste, Mr. Jarvis said. Of the first million homes built in Canada following the Second World War, only 2% were designed by architects. This was apparent, he said, in a recent report prepared by the Royal Architectural Society. An investigation committee visited 15 Canadian cities and found the same pattern of dullness in the buildings and discontent among the home owners.

"We are sacrificing standards of living for standards of having," Mr. Jarvis said.

The proper balance between theory and practice in engineering education was argued during a panel discussion at the final day of the Meeting.

Dean Dale E. Corson of the College of Engineering at Cornell University suggested engineering students require a large amount of theoretical knowledge. This, he said, would enable them to adjust to changing engineering practices and findings.

Norman A. Hall, Head of the Department of Mechanical Engineering at Yale, insisted that as engineering is a practising profession, there should be proper emphasis on practical courses.

"There is a very real problem involving the effective life of an engineer," Dean Corson said. "Conditions are changing so rapidly that an engineer 10 years out of college may fall behind. Many industries are demanding night refresher courses for their older engineers. Industry's only alternative would be to hire young graduate engineers who are on top of recent developments."

Dean Corson said student engineers must be taught relevant subjects so they can understand problems in depth. The greatest need is flexibility in some courses and in some schools.

"To face present problems we need engineers who are properly phased," Dean Corson said. "Our problems are so complicated we must bring all possible imagination to bear."

Mr. Hall said the ability to design is a basis for engineers and a basis in the E.C.P.D. accreditation program. Cul-

(Continued overleaf)

Senor Ortiz (centre) and Senor Davalos inspecting equipment at Sherbrooke's Canadian Ingersoll-Rand plant.

President's Column

NOW THAT the Fall season has arrived the Presidential Visits to Branches have commenced. These opened with the President and Mrs. Dick attending the Maritime Professional Engineers meeting at St. Andrews, New Brunswick. The Presidential party included Vice-Presidents Lawton and Higginson, and General Secretary Page. Past-Presidents of the Institute were represented by Dr. Ira MacNab of Halifax, Dr. John B. Stirling of Montreal and Dr. Clem Anson of Sydney, Nova Scotia.

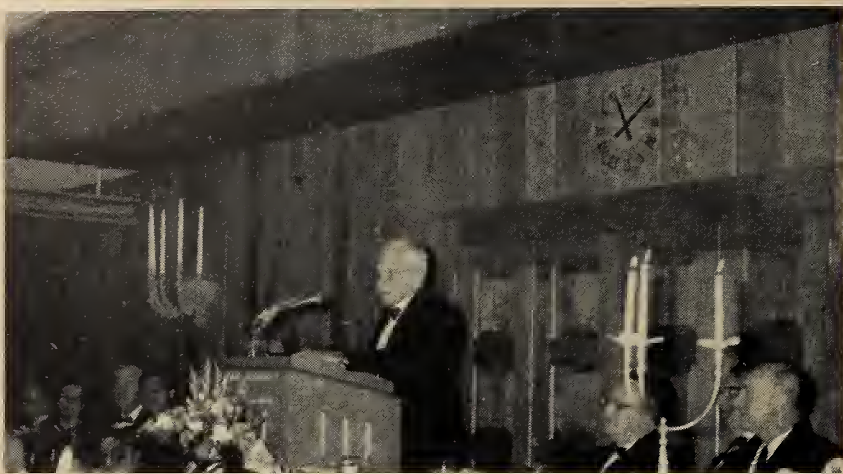
Your President had the honor of addressing the opening luncheon, and chose for his subject, as a token of appreciation of the fairer sex, "The Engineer and His Wife."

A meeting of the Executive Committee of the E.I.C. Council was held during the St. Andrews gathering, with the three Past Presidents in attendance, and several Councillors from Montreal and the Maritimes.

The President and Mrs. Dick proceeded from St. Andrews to visit Branches at St. John's, and Corner Brook, Newfoundland; Halifax and Truro, Nova Scotia; and Moncton and Fredericton, New Brunswick. The tour concluded with visits to Baie Comeau and Rimouski, Quebec. During this tour Vice-Presidents Higginson and Miller and their wives accompanied the Presidential Party through their respective districts, while the General Secretary also was present for the major portion of the program. Enthusiastic receptions were experienced at all points, while the meetings provided excellent opportunities for the President to explain the aims and objectives of the Institute, and to stress the desirability of the Branches developing increasing attention to the provision of technical programs.

The importance of maintaining increasing interest in membership was also pointed out, with mention being made of the new Membership Committee of Council recently formed under the chairmanship of Councillor Stan Cassidy of Fredericton.

The 28th Annual Meeting of E.C.P.D. was held in Montreal, October 3rd and 4th, and was a great success. The 4th Biennial ASME-EIC Conference on Engineering Education which followed on October 5th and 6th at Ecole Polytechnique provided an excellent opportunity for the study of future educational needs for Engineers.



Col. L. F. Grant addresses the E.C.P.D. banquet.

minating experience should provide the emphasis on practice rather than on theory.

Until about 40 or 50 years ago all engineering was basic and practical in approach, Mr. Hall said. In the 1920s and 1930s there was an endeavour to spread engineering curricula to handle new needs, resulting in the birth of such specialties as automotive, air-conditioning and aeronautical engineerng. Eventually ths broke down, he said, because it represented a constraint. This (theoretical) training caused engineers to lack the ability to forsee.

"It also caused the formation of Engineering Science . . . which today is an imperative tool, as drafting once was."

Mr. Hall concurred with Dean Corson that future training must be adaptable and flexible so that future problems can be met, because ". . . . the very nature of progressive engineering produces obsolescence."

Quebec's education system was described at the final luncheon meeting by Dr. Leon Lortie, Head of the Extension Department at the University of Montreal.

Dr. Lortie suggested Canada is losing many of its best brains to the United States not only because of the difference in salaries, "but to greater opportunities, principally in the field of research, academic as well as industrial."

"Very few industrial firms maintain research laboratories," he said. "Canada is greatly handicapped in this respect because few industries that are wholly owned by American companies invest capital or some of their earned revenue in fundamental research, which is always conducted in the huge laboratories of the parent company.

"An exception is the pulp and paper industry which maintains in Montreal the Pulp and Paper Research Institute in co-operation with McGill and the National Research Council where fundamental research on cellulose lignin and other constituents of wood has been going on for close to 35 years.

"It is true that U.S. owned companies based on the use of Canada's natural resources pay taxes, part of which is used for the maintenance and protection of education, but many Canadians feel that our country does not get a fair share of the profits gained from the depletion of these resources and, moreover, loses some of its best talent which is attracted to the laboratories built and operated in part with these profits.

". . . this is one particular aspect of a question with which more than a few Canadians feel uneasy."

The E.C.P.D. meetings were held at the Queen Elizabeth Hotel. Registered were 197 delegates and 30 ladies.

Engineering Education Conference

This biennial conference is sponsored jointly by the American Society of Mechanical Engineers and the E.I.C. and was held in Montreal in co-operation with l'Ecole Polytechnique and McGill University. Registered were 140 delegates and 10 ladies. Theme of the Conference was "The Engineer in 2000 A.D. — How Much Science in his Education?"

The business meetings all held at l'Ecole Polytechnique, were divided into four sessions. The first two, held in the morning and afternoon of Oct. 5, attempted to delineate the role of the engineer in 40 years. The following day's sessions dealt with methods of training the engineer of 2000.

Session I

The conference was opened with remarks by Dean Mordell and a welcome by Dr. Gaudefroy. Four presentations followed. These were made by: Dr. D. M. Myers, Dean of Engineering, University of British Columbia; Dr. P. F. Chenea, Head, Department of Mechanical Engineering, Purdue University; R. S. Sproule, Manager, Hydraulic Division, Dominion Engineering Company, Montreal; and Dr. G. N. Patterson, Director, Institute of Aerophysics, University of Toronto.

Chairman of the first two sessions was Professor Edward McHugh, Dean of Faculty, Clarkson College of Technology, Potsdam, N.Y.

Dean Myers said that engineers, as we know them today, will not exist in the year 2000. The most significant development and influence will be in the field of computers.

What has been done already in this field is not very significant, Dean Myers said, but it has opened the doors to limitless possibilities. Many jobs now being done by engineers are routine and repetitive. Any chore of this nature can be done more efficiently and economically by a computer. He said that as the invention of the steam engine replaced physical effort in many areas, so will the evolution of the computer replace much mental effort.

The biggest needs in the world today are in the field of communications, Dean Myers said. These are communications in the broadest sense of the word — the transmission of intelligence from person to person, from place to place, and from the past to the future. The principles of the modern computing device will have a profound effect on communications. There now are many examples, as control of telephone and cable communication, control of traffic, linear programming in the organization and movement of materials, factory processes and methods.

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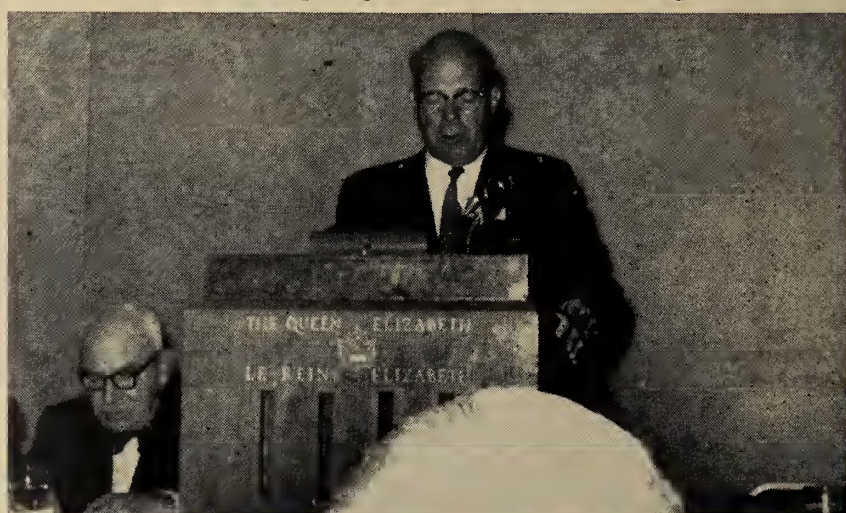
(Continued on page 114)

Mr. Everitt reporting to E.C.P.D. luncheon meeting.



PRESIDENT AWARDED HONORARY DEGREE by the UNIVERSITY of SHERBROOKE

President George McK. Dick has been awarded an honorary Doctor of Science degree by the University of Sherbrooke. The degree is in recognition of the important developmental work done by Dr. Dick towards the University and its Faculty of Science. In addition, the President, who is Chief Engineer of Canadian Ingersoll-Rand Company Limited, has made an outstanding contribution through almost five decades to Canadian engineering achievement.

Dr. Dick was born in Scotland and attended public schools there. After a short stay in the Canadian West he moved to Sherbrooke where he worked as an apprentice at Canadian Ingersoll-Rand. During the First World War he designed machinery for the manufacture of munitions.

He attended Bishops University in Lennoxville, Que., after which he entered McGill. He graduated from McGill in 1924 with a degree of Bachelor of Science, Honors in Mechanical Engineering. He was British Association Medallist at graduation and was holder of the Babcock and Wilcox Scholarship. His summer essay took prizes in the Canadian Pulp and Paper Association and the E.I.C.

Included in the early phases of Dr. Dick's diversified career was experience in the pulp and paper field and in the design of stockers and boilers

After re-joining Canadian Ingersoll-Rand Dr. Dick for many years was Chief Hoist Engineer, in which capacity he pioneered the design of many mine hoists used today in Canada. During the Second World War he was Chief Engineer of The Sherbrooke Pneumatic Tool Company, a subsidiary of Canadian Ingersoll-Rand and was responsible for the design of much of the shell manufacturing equipment used by this company.

Later he became Technical Assistant to the Works Manager of the company, a position he held until 1945, when he was appointed Manager of Engineering with duties embracing management of all phases of the company's engineering and technical activities. These duties later were broadened to include complete control of the company's purchasing program, and he became Manager of Engineering and Purchasing. Since his appointment in 1952 as Chief Engineer Dr. Dick has devoted his time principally to the development of new products, materials and processes.

Dr. Dick is a Past Vice-President of the Institute, a member of the American Society of Mechanical Engineers, the Technical Association of the Pulp and Paper Industry of the U.S.A., The Corporation of Professional Engineers of Quebec, The Canadian Institute of Mining and Metallurgy, The Canadian Pulp and Paper Association, and The British Association for the Advancement of Science.

He is a member of the Advisory Committee of the Faculty of Science at the University of Sherbrooke and has lectured there.

When he accepted the honorary degree from the University, Dr. Dick reviewed the achievements of Quebec since his youth, and outlined the technological and scientific advances the world has witnessed in the last 150 years.

"From all this review I can make only one suggestion," Dr. Dick told the convocation, "and it is this: we in Canada, as well as in the other countries of the Western World, must prepare ourselves mentally and technically to carry on this ever-changing program. We must be prepared to meet all challenges to our technical and scientific development on both the academic as well as on the commercial front.

"How can this be done? It can be done by only one method, namely more and better education. There is no short cut, no magic wand which can be waved to give us scientists, technicians and engineers. No country in the world has any simple method; just education in suitable and increasing quantities.

"Curricula must be steadily improved, teaching methods must be raised to maximum efficiency, and education brought within reach of all. The people of our country must be indoctrinated to show interest in the educational processes of our land, while governments must continue to expand their sympathetic assistance to provide funds."

The President sketched the racial and national influences in Canada and suggested these should be accepted as a challenge "to take the best from the magnificent educational legacy of our forefathers and to weave them into a sound and staple pattern in which to project the future educational fabric of our land."

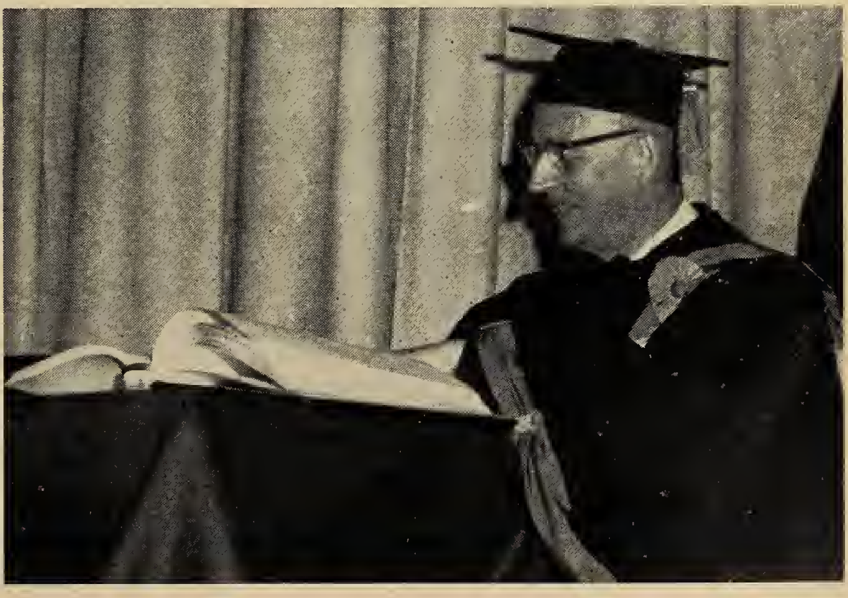
"While I have stressed the scientific and technical aspects of education, let it not be misunderstood that I have, in any way, minimized the wonderful powers of classical studies. A well balanced education discipline must be strived for. Languages, history, logic, philosophy, etc., still have a most important part to play and must be included.

". . . it would seem to be evident that what we need to take care of our technological requirements for the years to come will be more and better engineers and scientists. The men who come out of our universities with Bachelor's Degrees will require a higher standard of broad, as well as specialized knowledge, balanced with a suitable selection of cultural subjects, while those who go on to post-graduate work will also have to be equipped with more scientific knowledge and a greater degree of appreciation of direction, so that their efforts can be trained on the subjects which require attention, and suitable results produced in these fields with the greatest possible speed."

The culmination of the program was a testimonial banquet for Dr. Dick by the Sherbrooke Branches of the Institute and The Corporation of Professional Engineers of Quebec. Among the speakers were Sherbrooke's Mayor Armand Nadeau, C.P.E.Q. President Arthur Piches, Member of Parliament Maurice Allard, Institute Vice-President F. L. Lawton, Dr. J. B. Stirling, Chancellor of Queen's University and a past president of The Institute, and Institute Treasurer E. D. Gray-Donald.

In his banquet address Dr. Dick emphasized that the future of Canada is largely in the hands of engineers and that vision, enthusiasm and the will to work are necessary if this promising future is to be achieved. EIC

Dr. George McKinstry Dick



SESSION I—EDUCATION CONFERENCE

(Continued from page 112)

idiomatic expressions and other internal oddities of individual languages, it is not now possible to have effective translation done by computers. The evolution of a standard form of expression, possibly using different symbols, would allow computers to act as translators and thus would be a basic aid to proper communication.

Engineers must also recognize their social responsibilities, Dean Myers said. Management of world affairs now is in the hands of non-scientific people, and they have let the world down by not taking advantage of scientific advances.

Dr. Chenea felt that in 2000, engineers would still be the planners, doers, and decision-makers they are today — but that they will be doing these things in a different manner. Engineers of the future will not be interested primarily in scientific research, he sad. As today their basis will be design.

"The engineer in 2000 A.D. will live in a greater scientific community," Dr. Chenea said. "The scientific and technical environment will be larger, and he will get much more support from machines such as computers than he does today."

Dr. Chenea referred to science as it pertains directly to the engineers' operations. In addition to the physical, chemical and life sciences which form a background and source material for the engineer, there is a growing science of engineering design.

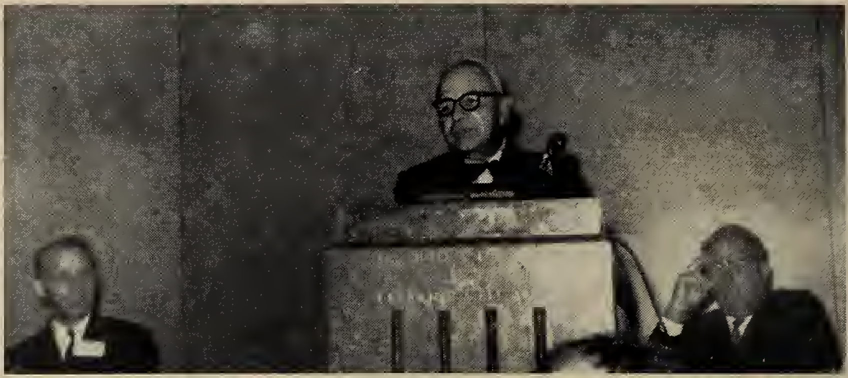
"I refer primarily to the new kinds of mathematics which have to do with hard-headed decision-making and the new kinds of techniques which are available for processing tremendous amounts of data," he said "Both of these will eat drastically into the engineering art and engineering judgement and replace it with rational, and, in some cases, routine procedures."

Computers have the two great advantages of speed and reliability, he said, but in spite of this, and with good reason, many present engineers look down their noses at such sub-human equipment.

"Problems of the future will put much greater emphasis on certainty, and these sub-human machines cannot provide it. Computers can relieve engineers of much of their routitne work and allow them to devote more of their time and attention to creativity . . ."

Dean Chenea said computers may put a great number of engineers out of work. He said General Motors Corporation now is using computers to design gears. Cost per gear design is 42 cents — the lowest charge which a computer can register. In contrast, he said, the best a $10,000-a-year engineer can do is to design two gears a day.

Mr. Sproule questioned the economics of space travel. He said ancient Egypt should provide a firm lesson of what can happen to a civilization if it devotes a disproportonate amount of money and energy on projects of questionable practical value. Egypt never recovered from the expense of building the pyramids,



Dr. Lortie outlines Quebec's education system at E.C.P.D. luncheon.

he said, and we could be endangering our civilization with an overly-energetic program of space conquest.

"Rocketry requires a disproportionate part of valuable engineering talent," Mr. Sproule said. "We should beware of carrying it to excess, and until it should be debated whether rocketry beyond the needs of actual or retaliatory defence is an excess."

Many of the top engineers of 2000 now are living, he said. They are engineering students or recent graduates, and much of their judgement in 40 years will depend on what they have been taught or are being taught.

There will always be a demand for men who can read drawings and catalogues, and who understand nuts, bolts, wheels and levers, he said, but these may not always be considered engineers. Mr. Sproule concluded that in 40 years there will be need for a greater proportion of mechanical engineers with what we now call Ph.D. training.

Dr. Patterson made a plea for a more scientific approach to engineering education. Engineering, development and research are inseparable, he said. Specialties should be expanded and post-graduate work should be considered indispensable.

"It is obvious," Dr. Patterson said, "that the days of the handbook engineer with his empirical outlook are numbered."

"The educational needs of the engineering scientist starting from first principles and not as an extension of the regular engineering course is a subject for urgent consideration," he said. "The place of the engineering research institute in the university and its vital function as the centre of training for the engineering scientist must be more clearly defined, and the needed development and support of such organizations must be given more serious attention."

Walker L. Cisler at the first luncheon meeting of the Education Conference. To his left are Dean Mordell and Mr. Dick.

During the first luncheon meeting, held at McGill, Walker L. Cisler, ASME President and President and Director of Detroit Edison Company, said engineers require a broad approach. They must never forget they are part of the world community and have social obligations to fulfil, he said. The guests were welcomed by Dr. F. Cyril James, Principal and Vice-Chancellor of McGill.

Session II

The afternoon session consisted of a panel of the morning speakers. Discussion was initiated by: Dr. G. M. Shrum, Department of Physics, University of British Columbia; Dr. L. P. Bonneau, Dean, Faculty of Science, Laval University; Dr. B. G. Newman, Professor of

Aerodynamics, McGill; and G. N. Martin, General Manager, Boiler Products Division, Dominion Bridge Company Ltd., Montreal.

Dr. Shrum said our sights are set too low, and that in Canada and the United States we are not lacking engineers — just good engineers. Many engineers just manage to pass their courses and after graduation do their jobs as mere technicians. Engineering education is extremely expensive, he said, and universities should not waste their time and facilities to train technicians.

Dr. Shrum said scientists should not be interested in the sociological side of their work. Sociology and similar professions should be left in the hands of those especially trained for such work.

He also disputed the phrase "sub-human" as a description of computers. "Computers are not sub-human," Dr. Shrum said. "They are super human. They are smarter than 99.9% of the people. It is argued that they are not creative, but extremely little creativity exists now anyway."

Engineers may be trained to make decisions on technical matters, he said, but their training does not necessarily qualify them to be decision-makers in other fields.

Dr. Shrum also said that today a man should not call himself a scientist until he has a Ph.D. degree. There is a need for engineers with Ph.D. degrees, he said, but the need is far greater in science.

Dr. Bonneau said he disagreed with Dr. Shrum that engineers and scientists should not concern themselves with the social aspects of their work. Engineers build tools and machines which create social problems, and they must take the responsibility for these problems. He said the engineer of 2000 must be conscious of his responsibilities, and suggested a balance of science and the humanities in engineering curricula.

Dr. Newman said we can be certain of some engineering in 2000 apart from the fields of computers and space exploration. A great deal of work must be done in the fields of agricultural engineering, nuclear electric power and weather control.

Mr. Martin said engineers, unwisely, are ignoring their social responsibilities. He also said there now is too much specialization in engineering and that this trend must reverse itself. "Fifty-percenters" will find there is no room left for them in the profession, and will be replaced by technicians.

By improving their present training, Mr. Martin said, engineers could become the leaders in industry. If engineers are to lead industries, then they must meet their social responsibilities. At this time, he said, we are not preparing engineers to be leaders.

Answering comments and questions from the floor, Dr. Patterson said while Bachelors of Science in aeronautical engineering sometimes have trouble getting jobs, Ph.D.s have 15 to 20 offers of jobs at top salaries. Top men always are in demand, he said.

Mr. Sproule commented that 50% is not a passing grade in industry. Dr. Chenea defined an engineer as a scientist with a sense of value. Dr. Myers said there always will be consulting engineers as they serve the needs of small, growing industries. In answer to a question from the floor he said he believed the trend towards specialization will reverse itself, although there always will be need for some specialists.

Banquet

The banquet was held at the University of Montreal and was presided over by Dr. Gaudefroy. Guests were welcomed to the university by its Vice Rector, Msgr. Deniger and to the City of Montreal by Mayor Sarto Fournier.

Guest speaker Dr. Karl Stern of the Department of Psychiatry at Montreal's St. Mary's Hospital said that people today view the future with the mixed emotions of strong apprehension and cheery optimism. He said it is unusual for people to look ahead with pessimism.

All previous civilizations were based on rural and agricultural societies — never on technological societies. Through all these, he said, man's attitude was not that of a conqueror of nature. Rather he had a child-like dependence on natural rhythms and recurrences. Great achievements were not in analytical areas, but in intuitive areas. It was the difference between wisdom and science.

The main disadvantage of this rural type of society, Dr. Stern said, was that it held the great danger of stagnation. Our present technological society is both restless and insatiable. In former times leisure moments were creative and contemplative. This has been replaced by empty leisure, and leisure activity has been replaced by leisure passivity.

He said it is unfortunate that the use of wisdom and intuitive intelligence wanes in an age of technology. But these problems inherent in our technological age can be solved, he said, and most probably the solution will come from a synthesis of research and wisdom.

Session III

L. A. Duchastel, Personnel Manager, Shawinigan Water and Power Company, Montreal, was the Chairman of the two final sessions. Presentations were made by: Dr. R. G. Folsom, President, Renesselaer Polytechnic Institute, Troy, N.Y.; Dr. E. W. R. Steacie, President of the National Research Council of Canada; Professor Dana Young, Department of Civil Engineering, Yale; and Dean M. P. O'Brien, Dean Emeritus, The College of Engineering, Berkley, Calif.

Dr. Folsom said that to serve the engineering needs of 2000 there must be greater emphasis on post-graduate work by engineering students. Theses will be design oriented rather than research oriented. Perhaps the degree received will not be a Ph.D., Dr. Folsom said, but it will be the equivalent.

In some schools many courses will be eliminated, he said. These will include surveying, electrical labs, and even drawing. By 1980 the basic engineering course will be five years, he said, and a greater number will go on to further studies. The technical type of institute will vanish.

Dr. Steacie said he could subscribe to neither of the extreme views of engineering education. It will be taught neither as an old craft, nor as a branch of applied physics, he said. Many science students follow post-graduate courses, but too few engineers do the same.

One of the biggest farces today, Dr. Steacie said, is the insistence on professional qualifications. Everyone wants a degree in his own specialty. He said he could see no reason why engineering should be a legally closed profession.

Two groups of engineers now are being lost to the profession, Dr. Steacie said. These are the technicians and the administrators. Many engineers go directly into administration because they feel engineering is a good general educcation. This problem could be resolved if humanities courses provided more science. In projecting engineering wants, we should forget numbers and consider needs, he said. Greater numbers of engineers will be required for some time, but eventually there must be a diminution in the number trained and needed.

"We cannot forever go on increasing the percentage of the population who are engineers," Dr. Steacie said. "One thing that could be done would be to eliminate the university trained engineers who become either administrators or mere technicians."

Professor Young said engineers have every bit as much social responsibility as others, both as persons and as professionals. Engineering education has made tremendous progress in recent years, but this work is not yet finished. The danger now, he said, is that the present impetus will carry too far and that science will overwhelm engineering curricula.

Bigger projects are being tackled by engineers, Professor Young said, and for this reason there is increasing activity in engineering research. The basic knowledge for these bigger projects is not now available elsewhere.

The engineer of 2000 will be exposed to greater numbers of courses in science, research and managerial functions, he said. The core of the engineers curricula will remain the same, although the details will be different.

Dean O'Brien traced the economic development of North America and said this came about under unusually favorable conditions. The energy and initiative of an immigrant population, tremendous natural resources, an uninhabited continent, relative freedom from inhibiting customs and traditions, and, over a long period, the absence of international competition and pressure, formed an environment well suited to the full exploitation of the industrial revolution.

"These circumstances never existed before elsewhere in the world," Dean O'Brien said, "and they can never exist again."

"We are awfully smug about what we have accomplished, but unless we change this attitude — and change it soon — we will be in serious trouble."

In the world of 2000 Dean O'Brien saw more authoritarian governments, particularly in under-developed nations. As population will continue to increase as fast as resources there will be a change in living standards. Under-developed nations will have higher standards while advanced nations probably will experience a decrease.

Private capital will be less important than government expenditure and "engineering will function increasingly under government support or administration," Dean O'Brien said.

World-wide economic competition will become sharper and the battle for engineering products and services will be decided ultimately on the basis of quality and cost.

In the education of engineers for this era he suggested continued emphasis on basic and applied science and on modern analytical techniques, but "exercises in creative design must be increased."

The basic engineering course will be at least one year longer, Dean O'Brien said, and specialists will require even more extensive education.

Institute President George McK. Dick, the luncheon speaker, suggested there are three characteristics which distinguish the "superior" and the "not quite so good" engineers. These are ingenuity, sound judgement, and imagination. If these characteristics are of value, he said, a way must be found to develop them in college.

"Possibly these traits can not be developed by teaching or by other methods," Mr. Dick said. " . . . on the other hand it would seem that if the development of these important characterisics were approached in the way of providing challenge to students while they are yet in reasonably plastic or pliable mental state, then the graduates might be better equipped than they would otherwise be if these important characteristics went unrecognized and uncultivated."

Session IV

This session grouped final comments of five scheduled speakers. A guest speaker was Michael Kostenko, Member of the Academy of Sciences of the U.S.S.R. Professor Kostenko teaches at the Institute Electromechanics at Leningrad.

Professor Kostenko expressed surprise that the development of hydro-electric power on the Hamilton River in Labrador is not being pursued with vigour. In such a scheme a broad outlook is needed. Professor Kostenko said he had been told of the Hamilton's great potential, but that it was not now economically feasible to develop it.

"To us this is a rather narrow outlook. In Russia when we determine potential power we set about to develop it, even though there is no industry in the area. We believe this brings better and quicker results."

Commenting on education problems, Professor Kostenko said that when he talks with a young student engineer he explains the student is being taught what the teachers themselves do not understand.

The other speakers at the final session were: Professor Frank Noakes, Head, Department of Electrical Engineering, University of British Columbia; Professor John F. Lee, Head, Department of Mechanical Engineering, North Carolina State College; Associate Dean R. C. Gildmacher, College of Engineering, New York University; Professor J. H. Keenan, Head, Department of Mechanical Engineering, Massachusetts Institute of Technology; and P. W. Gooch, Chief Engineer, Engineering Division, Canadian Vickers Limited, Montreal.

Professor Noakes forecast a populaton in Canada of 45 million in 40 years. Because of the present lack of decision concerning what should be taught engineering students, he said "the years between 1959 and 1999 will be known as the Age of the Curriculum Diddles." The four-year course will be expanded, he said, and there will be greater emphasis on post-graduate work.

Professor Lee said the pace of future change will be much more rapid than the pace of change in the past. The major factor in engineering education must be doubt—great, profound doubt. While the primary purpose of scientists and philosophers is to know, Professor Lee said, the engineer has another task—that of synthesis. He foresaw a division of engineering, with research engineers seeking knowledge and practising engineers applying knowledge.

Professor Keenan said the greatest future need in engineering will be engineering students. The percentage of engineering students is declining, he said. One reason is the drop in prestige in the public image. This prestige has swung from engineers to scientists.

"This swing was over due and was needed," Professor Keenan said, "but it may be going too far. And it has affected not only the students but the engineers themselves."

Scientists often are given credit for work done by engineers, he said. This must be rectified, and engineers must seek to improve their public image at every opportunity. One manner would be to explain constantly the difference between engineering and science.

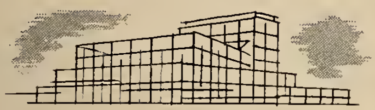
Associate Dean Gildmacher said that because engineering is sensitive to society, there will be many types of engineer in the future. Among the more important will be the engineering scientist.

"We would much prefer, when looking for a heavy project leader, to have an engineering scientist rather than a design man," he said. "I don't feel we can wait for the designer—we need the engineering scientist."

Mr. Gooch said he was impressed with the remarkable agreement among the various speakers. Our future needs, he said, will include designers, project engineers and the entire spectrum.

The most important thing a school can do is to teach a person how to learn, as education certainly doesn't end with a degree. While standardization of parts is essential to industry, Mr. Gooch said, we must appreciate that human beings are non-standard. For the education process to be successful more attention must be given to individual students and requirements.

Lead and Zinc are "behind the scenes" at the O'Keefe Centre



At Toronto's multimillion dollar O'Keefe Centre you will find lead and zinc contributing to the life of the building and the comfort of those who use it. Here are some examples.

O'Keefe Centre for the Performing Arts, Toronto
Architects: E. C. Morgan, Toronto; Page & Steele, Toronto

LEAD FLASHING

Over 4,000 square feet of lead-clad copper flashing were used. Its principal application was for through-wall flashing underneath coping stones as shown below. Both plain and corrugated sheet and strip were laid. Lead-clad copper combines the high strength of copper with the excellent corrosion resistance and non-staining characteristics of lead. Coating, both sides included, averaged 1¼ ounces per square foot.

Lead flashing

LEAD ANTI-CORROSION STRIP

Lead Anti-corrosion Strip

The upper exterior walls of the Auditorium are clad with corrugated bronze sheet panels. Bronze structural members carrying the sheets are secured to the main steel frame. The steel at its junction with the bronze would be subject to corrosion due to the electrolytic action caused by dissimilar metals in the presence of moisture. To prevent this corrosion 2-inch wide strips of 4-pound gauge lead were inserted between the joint faces of the two metals.

GALVANIZED DUCTWORK

Nearly 400 tons of galvanized (zinc coated) sheet were used to make up the extensive heating and ventilating system. Gauge varied from 26 to 16 and zinc coating was standard at 1¼ ounces per square foot (both sides included). The choice of galvanized sheet means long, trouble-free life, ease of fabrication into complex

Galvanized Duct Work

shapes, simplicity of installation and low thermal expansion to help keep duct noise to a minimum. The choice also meant real economy in initial cost at no sacrifice to future service.

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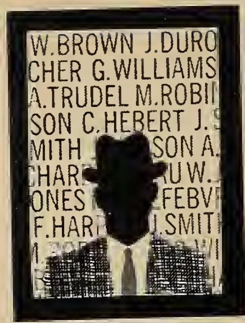
Personals



Hugh Crombie, M.E.I.C. (McGill '18), has been re-elected President of the Canadian Association of Machinery and Equipment Manufacturers. He is Vice-President and Treasurer of Dominion Engineering Works Limited.

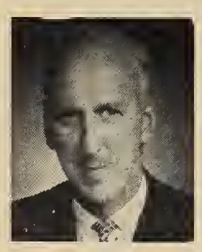
J. B. Nelson, M.E.I.C. has retired from H. G. Acres Company and is now consultant on structural steel design for service buildings, at the approaches to the new Lewiston Queenston International Bridge, for Salter and Flemming, Architects, St. Catharines, Ontario.

J. A. Mersereau, M.E.I.C. has been appointed as maintenance engineer of the highway division of New Brunswick. He has been associated with the maintenance branch since 1945.

Niel Metcalf, M.E.I.C. (Wales '25), has been appointed Assistant General Manager of Burlington Steel Co. Limited, Hamilton. He joined the company as Chief Metallurgist in 1936 and was made assistant to the general manager in 1955.

H. A. Gauvin, M.E.I.C. (McGill '26) has been appointed Deputy Minister of the Quebec Department of Public Works. Since 1956 Mr. Gauvin has been general manager for A. Belanger Ltee., stove manufacturers, Montmagny, Que.

Drummond Giles, M.E.I.C. (McGill '27), and **S. M. Finlayson**, M.E.I.C. (McGill '24), have been elected to the Board of Governors of McGill University.



C. A. Peachey, M.E.I.C.

C. A. Peachey, M.E.I.C. (Toronto '27), has been appointed vice-president and general manager, communications equipment division, for Northern Electric Company Limited.

Ronald C. Marriott, M.E.I.C. (Cambridge University), has been appointed Eastern Area Manager for Ruston & Hornsby Limited. He has had extensive diesel engineering experience in both Great Britain & Canada.

R. C. Marriott, M.E.I.C.

F. F. Fulton, M.E.I.C.

F. F. Fulton, M.E.I.C. (McGill '28), has been promoted from general manager to vice-president and general manager, telephone contract division, for Northern Electric Company Limited.

J. G. Little, M.E.I.C. (Toronto '28), has been promoted to the position of vice-president and general manager, wire and cable division, for Northern Electric Company.

J. G. Little, M.E.I.C.

T. E. Storey, M.E.I.C.

T. E. Storey, M.E.I.C. (Man. '28) has been appointed chief engineer of The Manitoba Hydro-Electric Board. He is now general manager of City of Winnipeg Hydro Electric System.

H. M. Brownrigg, M.E.I.C., (McGill '41) has been appointed vice-president in charge of steel foundry products for Dominion Brake Shoe Company, Montreal.

W. T. Hargreaves, M.E.I.C. (U.N.B. '46), has been named executive assistant to the Public Works Minister of New Brunswick. He has had 26 years of experience in the construction and maintenance field.

W. J. Riley, M.E.I.C. (McGill '48), past president of the Corporation of Professional Engineers of Quebec, was recently elected alderman of the municipality of Rosemere.

Hugh B. Hall, JR.E.I.C. (Toronto '48), has been elected President of American Hospital Supply Corporation (Canada) Ltd., a wholly owned subsidiary of AHSC.

E. I. Lexier, M.E.I.C. (Man. '48), has been appointed to the Board of Directors of Green Blankstein Russell Associates. He is presently Associate in Charge of Engineering.

J. Devlin, M.E.I.C. has retired from the position of Manager Industrial Sales for Texaco Canada Limited. He is now residing in Troon, Ayrshire, Scotland.

E. L. Mercer, M.E.I.C. (Toronto '50), has been made Vice-President of the consulting structural engineering firm of Robert Halsall and Associates Limited, Toronto.

Gerald S. Conger, JR.E.I.C. (N.C.S.C. '52), has been named plant manager of the modern Caldwell Linen Mills Limited, in Iroquois, a subsidiary of Dominion Textile Co., Ltd.

G. J. McGee, JR.E.I.C. (McGill '53), has been named Assistant Sales Manager Structural Products for Dominion Structural Steel Limited. He has occupied senior positions in the design, estimating, cost and sales departments.

Dr. J. D. Scott, M.E.I.C. (Queen's '54), has been appointed assistant professor of Civil Engineering at the University of Waterloo. He was formerly a consulting engineer on soil mechanics in western Canada.

E. A. Thompson, M.E.I.C.

E. A. Thompson, M.E.I.C. (U.B.C. '42), formerly Vice-President and General Manager of Canada Creosoting Company Limited, has been appointed Vice-President and General Manager of Siporex Limited.

● PERSONALS

James T. Cawley, M.E.I.C. (Toronto '43) has been elected Vice-President of District 4 of the Canadian Institute of Mining and Metallurgy. Mr. Cawley is Deputy Minister of Mineral Resources for Saskatchewan and is Chairman of the Saskatchewan Oil and Gas Conservation Board.

Robert W. Blackburn, JR.E.I.C. (U.B.C. '57) has accepted a position as DESIGN ENGINEER, Mechanical Equipment, Civilian Atomic Power Department, Canadian General Electric Co. Ltd., Peterborough, Ont. Mr. Blackburn was formerly with the Engineering Design Branch of Atomic Energy of Canada Ltd., Chalk River.

C. Zeglinski, M.E.I.C., (Manitoba '56) formerly employed by the federal government in Saskatoon, has taken a position as a mechanical engineer with the Winnipeg Public Works Department.

W. J. Brice, JR.E.I.C. (Sask. '55), has accepted a position with Renold Chain Company of England. He will be given a two year training course in England before returning to Canada to take up permanent employment with Renold of Canada. He was formerly a design engineer with the Atomic Energy of Canada Ltd.

James W. Young, M.E.I.C., will receive an Honorary Doctor of Law Degree in recognition of his contribution to science in Alberta by the University of Alberta.

M. C. Schofield, JR.E.I.C. (U.N.B. '58), has been appointed Plant Manager of Canada Wire and Cable Company Limited, Atlantic Division, Lancaster, New Brunswick.

If you have recently had an APPOINTMENT or TRANSFER, let *The Engineering Journal's* editorial department know about it for a PERSONALS item. If you have a recent PHOTOGRAPH, send that too.

Address all information to: *The Engineering Journal*, Editorial, 2050 Mansfield Street, Montreal 2, Que.

Other Societies

Royal Architectural Institute of Canada

The results of an exhaustive cross-Canada inquiry ". . . to investigate the broad range of problems associated with Canada's residential growth and development," are contained in a report issued recently by the R.A.I.C. The Report of the Committee of Inquiry into the Design of Residential Environment was prepared by its members, Peter Dobush, John C. Parkin and C. E. Pratt.

The object of the project was to study the design of residential environment and to determine how the architectural profession could contribute more effectively to the improvement of the quality of design and the layout of residential areas. To this end the committee investigated: objectives to be sought in the design and layout of the total residential environment; what factors now shape the residential environment, what factors encourage or discourage the achievement of these objectives, and what can be done to modify these factors; ways in which these objectives may be realized more fully, with particular reference to ways in which the architectural profession can contribute more effectively to their realization.

Outlined in the report are the committee's findings and recommendations covering topics which range from the whole cost of housing to the role of governments in this design process. One section deals with conditions which were observed to be present in good housing design.

American Association of Cost Engineers

The A.A.C.E. has named Chaplin Tyler of the E. I. du Pont le Nemours & Co., the recipient of its 1960 Award of Merit. The Award, the highest honor the Association can bestow upon an engineer, was given Mr. Tyler for his "outstanding contributions to cost engineering economics, analysis and its application to the chemical process industry." Mr. Tyler spent several years as an editor of Chemical and Metallurgical Engineering. He is the author of Chemical Engineering Economics and is a contributor to the Encyclopedia of Chemical Technology.

The Institution of Mining and Metallurgy

A. R. O. Williams, a managing director of Consolidated Gold Fields of South Africa, Ltd., and of New Consolidated Gold Fields, Ltd., has been elected president of Britain's Institution of Mining and Metallurgy. Mr. Williams, who will assume office next May, succeeds Professor David Williams.

American Society for Quality Control

The Montreal Section of the A.S.Q.C. held a day-long forum Oct. 22. Approximately 250 delegates from Quebec and Eastern Ontario attended the forum, the theme of which was "Control of Quality Vital to Sound Business Administration". Topics discussed included basic concepts of quality control, control laboratory measurements, design of experiments, gauging problems, quality assurance, quality costs, management aspects of reliability and quality control, sampling problems and tests of significance.

The Society of Naval Architects and Marine Engineers

The 68th Annual Meeting of this Society was held in New York City this month. Six technical sessions which included the presentation of 11 papers, were held following the meeting of Council. Presiding over the meeting was Rear Admiral Albert G. Mumma, USN (Ret.), who was elected Society President for a two-year term in 1958. The Society has approximately 7,600 members in regional sections on the Atlantic, Gulf and Pacific Coasts, the Great Lakes, Canada and Hawaii.

The Society of Mining Engineers

James C. Gray of Pittsburgh has been elected 1961 President of the S.M.E., a constituent organization of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Mr. Gray, Administrative Vice President, Raw Materials, U.S. Steel Corp., will succeed Dr. Arthur B. Cummins of Bound Brook, N.J. Succeeding Mr. Gray will be William E. Stephenson of Poali, Pa., who was selected President-elect for 1961.

Frontiers of Control

The first Joint Automatic Control Conference held in the United States took place this autumn at the Massachusetts Institute of Technology. The latest advances in the field of automation were discussed by some 450 engineers and scientists. The Conference was sponsored by the American Society of Mechanical Engineers with co-operation of the Institute of Radio Engineers, the American Institute of Electrical Engineers, the Instrument Society of America and the American Institute of Chemical Engineers. During the three-day session 57 technical papers were presented. These included papers concerning new techniques in control system theory, testing and programming for digital computers. A conference highlight was the report by a team of outstanding automatic control specialists on technical developments in Russia.

American Society of Civil Engineers

Nine new officers of the A.S.C.E. have been elected by mail ballot of the Society's 46,000 members. The President for 1961 is Glenn W. Holcomb of Corvallis, Ore. Two Vice Presidents elected for two-year terms are Donald H. Mattern of Knoxville, Tenn., and William J. Hedley of St. Louis. Six directors were elected for three-year terms.

Coming Events

Annual meeting, Institute of Radio Engineers, vechicular communications, Philadelphia, Dec. 1-2.

Electrical insulation conference, American Institute of Electrical Engineers, Chicago, Dec. 5-8.

International Congress and Exposition of the Society of Automotive Engineers, Detroit, Jan. 9-13.

Annual meeting, American Astronautical Society, Dallas, Tex., Jan. 16-18. EIC

The Associations and Corporation

The presentation of a $500 cheque to the Vancouver Public Library marked the incorporation of the valuable private library of the Association of Professional Engineers of B.C., into the technology section of the public library. Association President H. P. J. Moorhead made the presentation recently to Peter Grossman, director of the Vancouver Public Library. The cheque is the first annual grant from the professional engineers to the library for expansion and maintenance of the engineering section. EIC

Obituaries

G. W. Coward, M.E.I.C., retired chief engineer for Way and Works on the Argentine Railway, died April 2, 1960.

Humphrey George Berkeley Michell, M.E.I.C., specialist in light and power development, died August 15 in Montreal. He was 65.

Mr. Michell was assistant manager of international operations of the Montreal Engineering Company.

He was born in Miniota, Man., October 1, 1894 and was educated at Dulwich College, England, St. John's College, Winnipeg, and at the University of Manitoba.

From 1920 until 1926 Mr. Michell was distribution engineer for the Winnipeg Hydro Electric System. Later he became superintendent of transmission and distribution for the Mexican Light and Power Company and in 1934 was named chief engineer of the Mexican Tramway Company.

H. G. B. Michell, M.E.I.C.

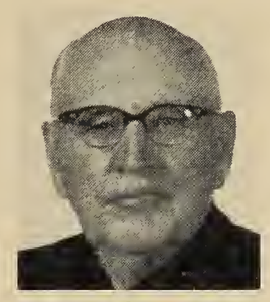
In 1939 he went to Bolivia as manager of the Oruro division of the Bolivian Power Company, and seven years later became general manager of the Bolivian Power Company, Limited, La Paz.

Mr. Michell returned to Canada in 1951 and was appointed to the operating division of the Montreal Engineering Company, Limited. Four years later he became assistant manager of international operations for the company.

He was a director of the Compania de Alumbrado Electric of San Salvador; the Monterey Light and Power Company, Mexico; the Demarara Electric Company, Georgetown, British Guiana; and of the Oriente Electric Company of San Salvador.

Mr. Michell was a member of the Engineering Institute of Canada; a fellow and life member of the American Institute of Electric Engineers, and a member of the Association of Professional Engineers of the Province of Manitoba.

Harold R. Miles, M.E.I.C., retired Division Engineer for Canadian Pacific Railway, Moose Jaw, Sask., has died. He was 81.



H. R. Miles, M.E.I.C.

Mr. Miles joined the C.P.R. in 1901 as Assistant Engineer in North Bay. In 1919, he was appointed Division Engineer in Lethbridge. He was transferred to Moose Jaw in 1933 where he retired in 1941.

Having joined the Institute as an Affiliate Member in 1902, Mr. Miles was given Life Membership in March, 1942.

Dr. David B. Steinman, M.E.I.C., designer of 400 bridges including the Mackinac Straits suspension span, died August 23 in New York City. He was 73.

Although graceful, long-span bridges were his specialty, Dr. Steinman considered the Brooklyn Bridge, built three years before he was born, the most beautiful in the world. From 1948 until 1954 he was in charge of reconstruction of the Brooklyn Bridge. Included in his achievements were: the largest suspension bridge in South America—the Florianopolis span in Brazil, and the Thousand Islands Bridge over the St. Lawrence River.

His earlier bridge projects included the Carquinez Straits cantilever in California, the Henry Hudson hingeless steel arch in New York City and the Mt. Hope wire cable suspension bridge in Rhode Island. At the time of Dr. Steinman's death the firm of Steinman, Boynton, Gronquist and London was working on an "intercontinental" span proposed construction over the Bosporus in Turkey.

Dr. Steinman was born in New York City and was educated at the New York City College and Columbia University. He was an author and poet and left technical books, papers, popular books and poems which were inspired by his devotion to the purpose and beauty of bridges.

Dr. Steinman was granted Life Membership in the Institute in 1960. He was a founder and first president of the National Society of Professional Engineers. During his career, 80 countries honoured him in various ways.

John T. Watson, M.E.I.C., Lethbridge's first city manager has died.

Mr. Watson was born and educated in Scotland. He came to Canada in 1902 and worked for the Canadian Pacific Railway in Calgary as a machinist. In 1916 he moved to Lethbridge and was made chief engineer at the power house. He left his position in the city in 1927 and was employed by the East Kootenay Power Co. until 1928 when he became Lethbridge's first city manager.

Mr. Watson held various offices in the Institute and was granted Life Membership in 1953. He also was given Life Membership in the Association of Professional Engineers of Alberta, the Lethbridge Chamber of Commerce and of the Masonic Lodge.

Archdale M. Wilson, M.E.I.C., chief engineer of the Algoma Central and Hudson Bay Railway in Sault Ste. Marie, died June 29. He was 61.

Mr. Wilson graduated from Queen's University in 1928 and in the same year joined the railway. He was involved in many of the railway's development programs, including total dieselization and major upgrading of roadbeds and bridges. He was instrumental in the mechanization of track maintenance. Mr. Wilson was promoted from assistant engineer to engineer maintenance-of-way in 1944, and nine years later was named chief engineer.

Mr. Wilson was a member of the Association of Professional Engineers of Ontario, the Toronto Railway Club, American Society of Metals and was a member of various educational boards in Sault Ste. Marie.

News of the Branches

Amherst

G. R. Pond, M.E.I.C.,
Correspondent

A group of members and their wives drove to Moncton, Sept. 15 to attend the banquet and dance sponsored by the Moncton Branch during the visit of Institute President George McK. Dick. Two weeks later the annual meeting and the election of officers was held. Members of the new executive are: Chairman G. R. Pond; Vice-Chairman L. L. Spuir; Secretary-Treasurer G. B. Turnbull; Past Chairman G. C. L. McEnery; and Executive members H. M. Smith, W. G. Miller and J. R. MacQuarrie. A film outlining the production of paper was shown following the meeting.

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

Engineers' wives received a tribute from Institute President George McK. Dick during a recent visit. Mr. Dick said the wives can play an extensive and important part in influencing the professional careers of their husbands. The President exhorted the engineers themselves to become more conscious of their own nation regarding professional requirements in Canada in both training and in the acceptance of ideas alien to Canada. He criticized Canadian engineers for their too-ready acceptance, at times, of United States and European influence. Institute General Secretary Garnet T. Page outlined the activities and responsibilities of the Institute and of the importance of the Branch Executive in guiding the technical training of young engineers, and of Branch meetings as a medium of exchange of technical information.

Border Cities

Wallace A. Macdonald, JR.E.I.C.,
Correspondent

A visit to the Leamington plant of H. J. Heinz Company of Canada Ltd. — one of the largest tomato processing plants in the world — was made Sept. 15 by members, their wives and their guests. The tour coincided with the height of the tomato season and members of the tour were shown the various stages in the processing of ketchup and tomato juice. These ranged from the unloading and preparation of containers and tomatoes to the cooking and canning methods. Of particular interest was the experimental kitchen, where recipes are prepared, and the adjoining laboratory where analyses and tests check nutritional value and quality. M. S. Dixon, company Vice President-Manufacturing, explained a system pioneered at Leamington in which sterilized tomato solids are stored in large, outdoor tanks for year-round processing.

Cape Breton

Lloyd Boutilier, M.E.I.C.,
Correspondent

A group of Cape Breton Branch members travelled to Truro, N.S., Sept. 15 for an informal dinner meeting with Institute President George McK. Dick, T. C. Higginson, Vice President-Maritimes, and their wives. Another representation, from the New Glasgow and Truro areas, headed by J. E. Clarke, also was present. The members found the meeting pleasant and profitable. Following the dinner the ladies were presented with bouquets of roses and the men with Nova Scotia tartan ties. One of the New Glasgow members piped the official party on its way to Moncton.

Chalk River

J. L. Gray, President of Atomic Energy of Canada Limited described a recent tour of Russia's power installations at the opening meeting of the Branch's 1960-61 season. About 250 members and guests attended the meeting during which Mr. Gray showed movies to illustrate his talk. The functional equipment was quite impressive, Mr. Gray said, but little attention had been given finishing detail. Construction of homes was low quality, and everywhere there were crooked windows, poor tiling, rough finishes and generally poor construction methods. Moscow University was found impressive, with its 45,000 rooms — 22,000 of which are in the main building.

R. O. Sochaski, M.E.I.C.

Halifax

H. F. Peters, M.E.I.C.,
Correspondent

A lobster dinner party at the Shore Club, Hubbards, N.S., was held Sept. 13 for Institute President George McK. Dick, Mrs. Dick, T. C. Higginson, Vice President-Maritimes, and Mrs. Higginson. Mr. Dick said engineers should give more recognition to the part played by their wives. In outlining Institute problems, Mr. Dick said a larger membership is required. He referred also to the problem facing engineers generally of maintaining their status in the community. All engineers must increase their technical knowledge, the President said, and must build the prestige of their profession. Members must work for a larger membership, and must generate general interest in the Institute. The dinner was attended by 114 members and guests.

Kitchener

A. R. LeFeuvre, M.E.I.C.,
Correspondent

Some 50 members participated in the opening event of the Branch's new season. They attended a stag on the property of the Waterloo County Fish and Game Protective Association. Following an outdoor sparerib dinner there were competitions in horse-shoes, golf, bingo and nail-driving.

Moose Jaw

T. L. Salmon, M.E.I.C.,
Correspondent

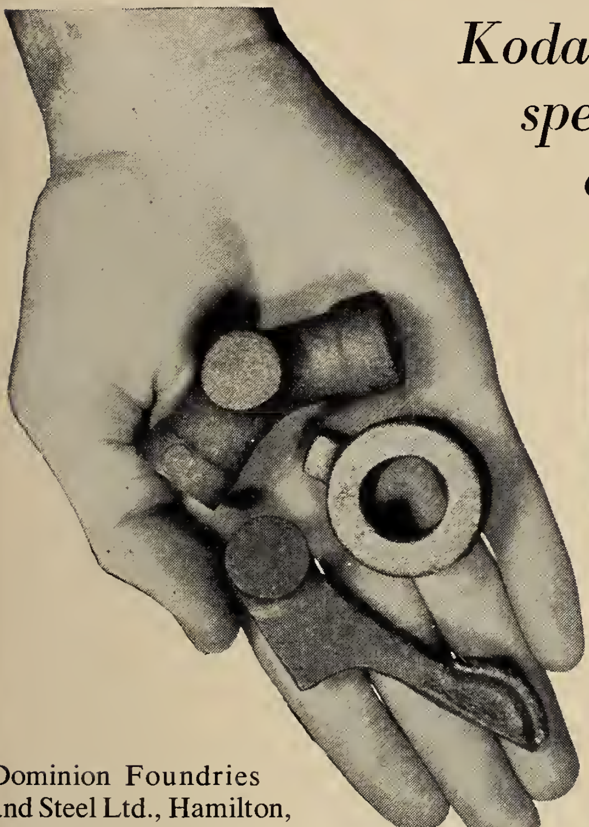
Eighteen members started the new season with a 115-mile trip north to the South Saskatchewan River damsite. Jim McMoran, P.F.R.A. engineer, greeted the group and conducted them on a four-hour tour of the immense project.

Niagara

E. C. Little, M.E.I.C.,
Correspondent

The annual Engineers Dinner and Dance, attended by about 450 engineers and guests, started the Branch's fall program Sept. 20. Two weeks later some 45 engineers registered for a Professional Development Program. Chairman of the Program is George Takata, who welcomed the engineers to the first of weekly meetings which will continue through the winter. S. N. Tibshirani, chairman of the Niagara Branch of the Professional Engineers Association, complimented the Institute on its program and offered full support. The purpose of the program is to assist engineers to become well spoken, well informed, and interesting persons who are good citizens and a credit to their profession. Carefully selected lectures, group discussions

Palm-sized or 30,000 lb. giant



Kodak Industrial X-ray Film speeds the quality control of castings—any dimension!

Dominion Foundries and Steel Ltd., Hamilton, boasts of one of the most versatile and best-equipped non-destructive testing departments in the industry. With Canada's largest cobalt source, Industrial X-ray Film guards the quality of castings from a mere 6 ounces in size to double-flange castings weighing 30,000 pounds each!

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Toronto

D. R. Abbey, M.E.I.C.,
Correspondent

"Missile Age Research" was the theme of a visit to the Institute of Aerophysics which started the Branch's 1960-61 program. The Institute of Aerophysics is a teaching institute of University of Toronto and conducts research at the post-graduate level and beyond. After being welcomed and briefed by Director Dr. G. N. Patterson the members were given an outline of various areas of research conducted. Equipment was inspected and explained throughly with the assistance of schematic drawings. The visit was organized on behalf of the E.I.C. by W. E. Lardner.

Vancouver

D. R. Bakewell, M.E.I.C.,
Correspondent

Fifty members visited the Burrard Thermal Power Plant, Oct. 1, as guests of the B.C. Electric Company and International Power and Engineering Consultants Ltd. W. I. O'Hara, Vice President, Civil-Mechanical Design Division of IPEC, gave a pre-tour briefing of the mechanical and electrical installations now under construction. Ultimately the plant will have six gas-fired boilers and turbine-generator units of 157,500 kw. each. Total cost of the plant and auxiliary works will be approximately $95 million. The civil work in the generating plant is mostly complete. The boiler plant and turbine installations for the first unit are scheduled to be finished early next summer. The electrical installation is in a primary stage. Institute General Secretary Garnet T. Page visited Vancouver Sept. 27-28 to assist in organizing the Central Committee for the Annual General Meeting next spring. Dean David M. Meyer of the Faculty of Applied Science of the University of British Columbia is the Chairman of the Central Committee. Other members appointed to date are: W. G. Heslop, Vice Chairman; F. Cazelet, Secretary; Commodore A. C. M. Davy, Western Field Secretary; J. H. Swerdfeger, Branch Chairman; and D. R. Bakewell, Treasurer.

Winnipeg

A. C. Warrender, M.E.I.C.,
Correspondent

Members of the electrical section of the Branch were guests at the Selkirk Power Project of the Manitoba Hydro Electric Board. After being welcomed by Bob Manning, Superintendent of the steam plant, and Art Williams, chairman of the electrical section, the group broke into smaller units for the tour. The first stage of the 1,000,000 kw. development consists of two 66,000 kw. steam turbo generators. The boilers, capable of producing 625,000 lb. of steam per hour, use lignite "bug dust" fuel from the nearby Saskatchewan lignite coal fields. EIC

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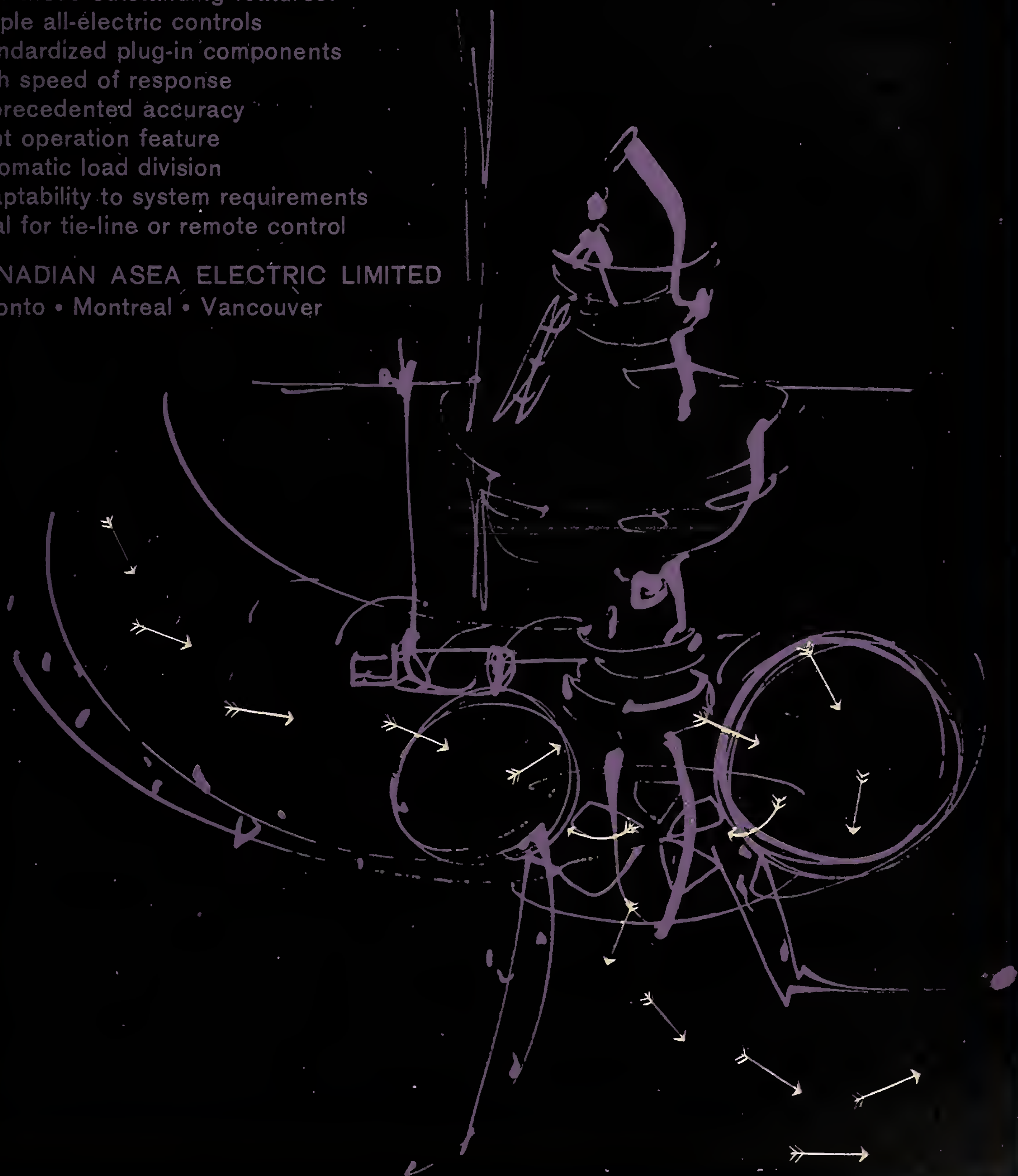


E.I.C. ELECTIONS & TRANSFERS

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective September 9, 1960.

ALBERTA

Junior: D. H. Meley
Junior to Member: V. F. Elliott
Student: I. M. Robison

SASKATCHEWAN

Members: B. A. Anthony, S. F. Bird, F. F. Gauld, E. B. Tinker.
Junior to Member: A. D. Carlson, B. L. Kilpatrick, D. D. McLean, D. E. Mortin.
Student to Junior: R. A. Doull, F. V. Fowke, W. F. Thiele, G. W. Wortman, M. J. Yablonski.
Student: A. H. Maandag.

NOVA SCOTIA

Junior to Member: D. W. Clark, J. R. D. Kaulbach.

NEW BRUNSWICK

Junior to Member: B. Beaton.

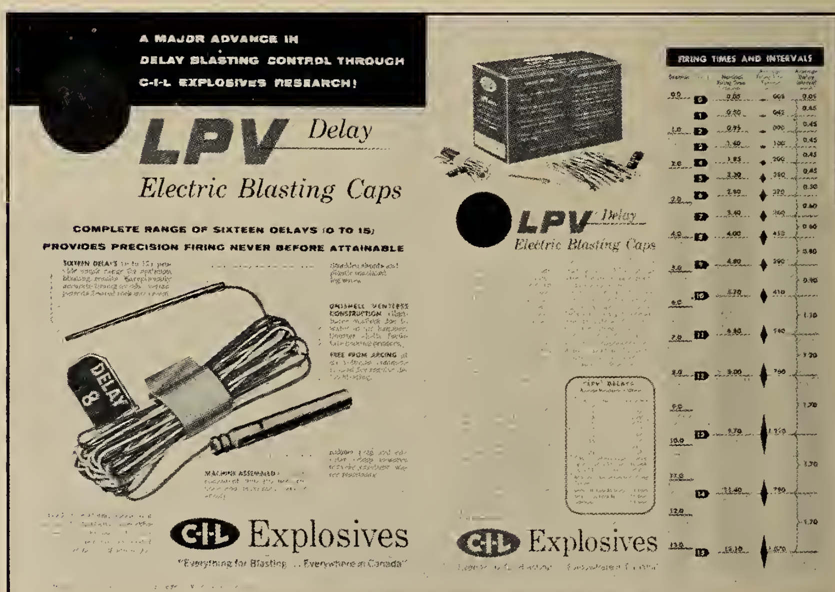
Next Issue
of
TRANSACTIONS
Vol. 4 No. 3

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Canadian Industries Limited, Explosives Division, three colour, two page insert in the August 1960 issue was judged the "best" by a fifty reader jury.

The advertisement appeared as pages 33 and 34 of the issue. It features LPV Delay Electric Blasting Caps. The insert is very striking in appearance. The text describes the range of delays obtainable through the use of these new electric blasting caps. The reverse side presents a tabulation of firing times and intervals.

The advertisement was prepared and placed by Cockfield, Brown & Co. Ltd. of Montreal — B. Fuller, Account Executive — the Advertising Supervisor for C.I.L. Explosives Division is W. L. Hill. This is the second time C.I.L. Explosives Division has been awarded the E.I.C. Certificate of Advertising Merit since the inception of the award in January 1959.



C.I.L.'s CERTIFICATE WINNING ADVERTISEMENT

The above illustration shows the front and reverse side of the C.I.L., Explosives Division, three colour, two page, insert which appeared in the August 1960 issue. This insert was judged the "best" from the viewpoints of ACCURACY—INFORMATION—ATTRACTION by a fifty reader jury.

The insert is printed in three colours — black, blue and red. The copy is concise and factual.

The Advertising Supervisor for C.I.L., Explosives Division, is W. L. Hill. The advertising agency is Cockfield, Brown of Montreal, and B. Fuller is the Account Executive.

● DISCUSSION

(Continued from page 101)

gas turbine has long been promoted as a peak shaving device, and as far as the field of power generation is concerned it is certainly not ideally suited to peaking. With a provincially interconnected power system any thermal generating unit smaller than 20-25,000 kw. is approaching the point where it is too small to be effective, yet the 20-25,000 kw. gas turbine is a mammoth machine compared to the light and compact aircraft power plant. As such, the time lapse between starting and full load is essentially the same as for a steam turbine, once the boiler has been brought up to operating conditions. The application described in this paper retains its versatility, and if it is economically justifiable, then this is presumably the method the utilities would like encouraged. If these smaller units can be procured for a reasonable investment per kw of installed capacity then the combined economics of the power generation should be improved, since the capacity factor of the generating equipment and the load factor of the system will be higher.

Despite the many intangible advantages and indirect economic possibilities the author has kept his analysis simple and direct. In my estimation he has, by a conservative approach, shown that the savings are sufficient to be considered justifiable for a utility or an institution.

Because this is a peaking application and because the cost of fuel is so attractive, the whole criterion in the selection of the type of gas turbine to be used should be one of low initial investment. The given tabulation of operating costs does not indicate this for the fixed element of these costs contains no item for interest on the invested capital. If the interest is taken as 6% the fixed charges then total 8 mills per kwh., which is the largest single cost item. The complexity introduced by the free power turbine is probably justifiable because of the extra operating versatility and the improved efficiency range. However, the cost of the heat exchanger can only be charged against the difference between the cost of high level Btus and low level Btus and under these conditions it would be extremely difficult to justify.

The operating costs show no allowance for maintenance. Maintenance is related to the length of time between reblading and other necessary repairs. The labour costs were worked out directly and in my estimation they are high enough to cover maintenance as well as daily operation. But if reliability is desirable in this, or a multi-unit installation of this type, a full inspection schedule would be a necessity. There are certainly some parts around the combustion can and system that are going to require cleaning, and in all likelihood, replacing.

At this state of the development of the industrial gas turbine, few would accept the life of the blades as 40,000 hr., and therefore assume the casing would not need to come off for twenty years. Not only does this imply that the engine is going to run out its life a full load, but that temperature cycling does not exist or it does not effect the life of the blades. Although natural gas is an ideal fuel, the 40,000 hr. life of the blades is extrapolated from creep test data based on 1000 hr. tests and although extrapolating from 1000 hr. to 40,000 hr. is thought acceptable, metallurgists are not fully acquainted with the effects of thermal cycling on fatigue or creep. Thus I think it would be prudent to inspect the blades every 10,000 hr. replacing the blades whose elongation is beyond a certain predetermined amount. Or to state the maintenance problem another way, "If the turbine inlet temperature is relatively low, it would be safe to use steam turbine maintenance methods at costs (.35 mills kwh.), but if the turbine inlet temperature is approaching aircraft propulsion practice, maintenance schedules keyed to aero-engine maintenance practice should be set up and analyzed".

Again, on the desirable side of the balance, the cost of 28.8¢ per thousand lb. of steam should contain some allowance for the capital investment of the steam generating equipment. This figure could well be $1.00 per 1000 lb. even as an inter-departmental charge and some 50 to 100% greater if it were to represent a selling price.

Professor Panar has indicated that the savings made possible by the peak shaving would yield a return of 8.45% on the capital invested. The analysis is conservative and the saving may well be of the order of 10 or 12%, however, each by-product power or by-product steam cycle must be analyzed on its own merits, and an industrial firm requires a better return on an investment, even before taxes, in order to make an expenditure worthwhile.

Discussion by A. A. Scott, and Paul G. McConnell, M.E.I.C.

Mr. Panar has provided some good and interesting data on the operation of a small gas turbine as a peaking unit. However, it must be realized that the installation described is special in a number of ways. These special features must be realized in considering applying a small gas turbine as a peaking unit in an industrial plant. Specifically, we have noticed the following:

First, regarding the economic analysis:

The system described is rather special because it incorporates not only purchased power and a gas turbine, but also a steam engine generating system. This makes the system described quite unusual and so the results obtained do not necessarily indicate the results that might be obtained from an economic analysis of any other system.

It is questionable whether many industries could justify using money at a 6% interest rate, as quoted in the paper.

Second, is the matter of the standby and emergency. What happens if the unit has to be taken out of seıvice over a peak period? There seems to be two alternatives:

Either the industry goes without power, and the possibility of this is something that should be factored into the economic analysis. Or, power is purchased in the emergency and this in turn brings up two points:

1. If the utility has to provide a service capable of taking the peak in an emergency, it will do so at no charge. This is the Customer element of cost to which Mr. Panar referred;

2. If a new demand is established, the economics of the gas turbine, of course, go out the window, and this is a possibility that should be factored into the economic analysis.

Third, the Paper is, of course, describing one particular system, and therefore does not deal with alternatives that should be considered in any contemplated installation, such as, the use of back-pressure and/or extraction condensing steam turbines depending upon the balance of the kilowatt hour and steam required.

Discussion by E. W. Hill, M.E.I.C.

This paper outlines the essential considerations in applying a gas turbine and in particular, its economic evaluation in conjunction with purchased power, steam turbines and process steam. The method used in evaluation is clear and this installation unquestionably pays its way. However, there are special circumstances about the University of Alberta that make this installation economic, whereas an evaluation in other areas would not prove such an installation economic.

(1) *Fuel Cost*

23¢/BTU x 10^6 is a fuel price that will seldom, if ever, be matched elsewhere in Canada. In other areas, fuel prices (either natural gas or residential oils) are in the range of double to triple the fuel rates in Edmonton. These higher fuel costs put a very different slant on most possible applications for gas turbines.

In Edmonton, the more the gas turbine is operated, the less will be the total cost of power.

In areas with high fuel costs, the reverse situation is the case. In these areas, gas turbines are justified by the lower capital cost/kw. of gas turbines compared with steam units or hydro power. Actual energy charges for the gas turbine will be higher than from other sources of generation, and will tend to effect the capital savings. Consequently the gas turbine is applied and sized to take peak load demands and run with a very low load factor, (at the most 20%).

In effect, on a demand basis, a gas turbine costs about 20/kw/year and other generation about 35/kw/year. Whether this saving can be realized, depends on how *little* fuel is actually consumed for energy.

(2) *Unit Size*

The capital cost of 150/kw for a gas turbine of 1890kw. size is much lower than would normally be expected. Larger units in the 10Mw. to 25 Mw. range can be bought for $90 to $125 per kw. depending on the exact rating given to the gas turbine. However, in the range 3000 kw and below, it has been our experience that diesels are usually much cheaper. It is in the 5 Mw. to 20 Mw. range that gas turbines usually turn out to be the most economic unit.

It is doubtful if gas turbines of such small size would sell at prices in the $150/kw. range today.

In spite of these special circumstances, the author has presented a clear and complete method of evaluating gas turbines, integrated with other sources.

AN RCAF EXERCISE IN OPERATIONS RESEARCH

A. B. Howell, M.E.I.C.

Wing Commander, RCAF, Westin, Manitoba

The Engineering Journal November 1960, p. 72

Discussion by J. P. Jeannoit

This paper presents an analytical study on the complex problem of aircraft maintenance and credit should be given to its author for the interesting relationships and integrating work load and manpower requirement.

Even at its present level of complexity, the analysis has to rely on some approximate expressions and simplified assumption which as the author himself points out requires careful verification prior to application.

One important corner stone of the analysis is the linear relationship found to exist between (Ru/Ns) and (F/Ns). The author does not indicate whether this relationship has been found to vary with aircraft total time and type and frequency of maintenance activity, as it seems often the case. The assumption of a constant (Ru) in time implies that the probability density function of an aircraft becoming unserviceable can be expressed by an exponential function. Such a verification would provide worthwhile support to the analysis.

The equilibrium relationship ($Ru = Rs$), can only be seen to hold true if Rs is not a pure serviceable rate but contains a large hidden idle time buffer (many queueing studies have illustrated this fact). If the true servicing rate was equal to the rate of becoming unserviceable, a queue of unserviceable aircraft would keep building up affecting (Ru) until an equilibrium would be reached for $Ru < Rs$.*

Steady state equations being designed to use average values without apparent consideration to random fluctuations in studied rates, say Rs and Ru, the model does not seem to permit assessment of minimum guaranteed serviceability or operational readiness.** There would be considerable advantage to establishing how much real random fluctuation can effect the validity of the steady state equations. We note that the problem of the random fluctuations is considered insignificant by the author in his discussion of the transient state.

The author's approach in deriving an optimum method of allocating manpower between inspection and repair work can be subjected to discussion. This approach seems to give equal weight to the problem of minimizing the number of unserviceable aircraft and the number of crew turnover. For many an operator this viewpoint is unrealistic.

Finally, the transient state equation appears to provide a good method of assessing the average impact of a changing rate of unserviceability (Ru) such as in the case of a change in the frequency of work and inspection periods. The equation may be valid providing the change in handling does not noticeably disturb the established relationship between the rate of unserviceability and flying intensity $(Ru/Ns) = f(F/Ns)$.

This paper is a forward undertaking in an area where little as yet has been done. Personally, I feel that this area of study can be somewhat classified as a queueing problem. Other attempts, of much smaller scope, have yielded a fair amount of success through the use of queueing theory.

However, a queueing model can present considerable difficulties in as much as the mathematics of queueing theory still have quite a bit of development to undergo.

Probably one of the best exposition of queueing theory and its application can be found in Prof. Morse's book, "Queues, Inventories & Maintenance". A problem of the magnitude presented would ultimately require the use of a digital computer to set up a dynamic model of the maintenance queueing problem and analysis of the type presented in this paper will certainly provide essential knowledge on the effect and interaction of the many variable present in such a model.

Author's reply.

Mr. Jeanniot's kindness in his opening remarks is appreciated. I will answer his observations as they arise in his commentary.

Change of (RU/F) With Time

There is indeed a change in rates of becoming unserviceable for a given flying rate as the aircraft changes its state in the course of time. One would expect, as Mr. Jeanniot observes, a very high (RU/F) ratio for an aircraft newly from the drawing board. This ratio should descend abruptly during shake-down of the type, then continue to descend at an ever-lessening rate to a plateau from which in time through deterioration by aging the value of (RU/F) might be expected to rise again. The data so far collected has not been gathered over a long enough period to show significant change, as all aircraft types involved were well stabilized in use.

Arrival and Servicing Rates Being Equal

In cyclic systems where the cycle includes items in use as well as in queue and in repair and where there is a state of equilibrium, the elements of RU and RS as used in the paper must be equal; if this were not so, the numbers of serviceable and unserviceable aircraft would change in number and equilibrium would be lost.

The *individual* rates of arrival and servicing which we may designate as $\lambda = (1/TS)$ and $\mu = (1/TU)$ are *not* equal but $\lambda N_s = RU = RS = \mu N_n$ at equilibrium.

A current reference on this may be found in the Operational Research Journal for May—June 1960 in an article "Finite Queues and Cyclic Queues" by Ernest Koenisberg.

Fluctuations Within a State of Equilibrium

I am sorry to have given the impression that random fluctuations within a state of equilibrium were considered insignificant in every context. Such fluctuations are *not* important when analysis is applied in increments of 1500 flying hours or more which for a large population of aircraft means a period of a week to 10 days. But when analysis is applied to shorter units of elapsed time (significantly less than 1500 flying hour increments) then the variations *are* important.

The area of analysis for increments of more than 1500 flying hours is essentially deterministic in nature. The area of analysis for small flying increments is probabilistic and density functions for the probabilities involved will have to be determined before a probabilistic solution is possible. I hope that data collection can be refined enough to provide the information required.

The Transient State

Mr. Jeanniot's remarks on the development of transient state equations and the optimum method are well taken.

I wish to thank Mr. Jeannoit for a useful and informed critique.

*"Queues, Inventories & Maintenance", by P. M. Morse. Publication in Operations Research #1, Wiley 1958.

**"The Employment of Failure Data in Logistic Planning", by Jay B. Heyne and Lewis Brothman. System Analysis Laboratory, Hughes Aircraft Company, Culver City, California. Paper presented at the 14th ORSA National meeting, October 24, 1958, St. Louis, Mo.

OPTIMUM ADJUSTMENT OF GOVERNORS IN HYDRO GENERATING STATIONS

L. M. Hovey, M.E.I.C.

The Manitoba Hydro Electric Board, Winnipeg.
The Engineering Journal, November 1960, p. 64.

Discussion by C. L. Avery

The discussion in this paper of convenient methods for field checking certain governor characteristics which affect unit stability and of the mathematical background should be of value to anybody involved with field adjustment of governors. The methods used are quite valid, assuming that the governor has first been found to be mechanically satisfactory from the standpoint of dead band, resolution, dashpot clearance, lost motion, etc.

The optimum values to which the various units on the Manitoba system were set are those determined by analog computer studies and do not include system self-regulating effects. Since the values so determined are based on purely resistance load governors so adjusted should be quite stable on normal system loads.

It would be interesting if Mr. Hovey would elaborate on what improvements in system operation were noted as a result of these adjustments or what tolerance in the adjustments could be allowed before system control is adversely affected.

In the case of the Manitoba system, the water time constants of the dominant plants are approximately the same and setting the individual dashpot time constants as a function of the weighted mean of the system is apparently satisfactory. Where the hydraulic time constants vary greatly between plants on a system it would appear more valid to base the dashpot time constants on the individual plant hydraulic characteristics. It can be seen from basic consideration of the factors affecting any single machine that, while the mechanical inertia tending to stabilize any disturbance is the total inertia of the connected system, the disturbance produced by hydraulic inertia is that pertaining to the unit itself. In other words, while the rotating masses are coupled together the hydraulic masses are not.

The author is to be commended on his very complete discussion of the general problem and this paper is a valuable contribution in a field of great interest to operators of independent power systems.

Discussion by R. Harland

Of the interconnected plants on the Winnipeg River, City Hydro owns and operates those at Pointe du Bois and Slave Falls. As a result, my first concern on reading Mr. Hovey's paper was the way in which common values of T^T and δ would affect the operation of these plants, especially since Slave Falls machines are vertical, propeller type and relatively slow, while Pointe-du Bois uses horizontal, Francis type, medium speed units.

The calculated responses of these plants individually, using Mr. Hovey's suggested values, led to the similar investigation of other plants. These responses are interesting, varying from dead-beat at Point du Bois and practically so at Seven Sisters, to cases of border-line stability at Pine Falls, and a high degree of instability at McArthur.

I therefore have three questions for the author:—

1. If my calculations are correct, and the response of McArthur is unstable, these machines could never be synchronized. Obviously this is not the case in practice. Why?
2. If you integrate the individual response curves of Pointe du Bois and Slave Falls from 0 to 1.28 seconds, you get the per unit drift of each plant from 60 cps. The difference is the number of cycles they tend to pull apart. For a 1 pu step function of load, this exceeds 340 electrical degrees. This must be resisted by the flow of synchronizing power between plants. Has Mr. Hovey done any stability studies under this or similar conditions taking into account governor response?
3. Considering the diversity of shapes of the response curves using Mr. Hovey's suggested values of T^{τ} and δ would it not be preferable to fix his stability criteria 2_1 and 2_2, making at least the shape of the response curves similar, and calculate appropriate values of T^{τ} and δ for each plant from these criteria?

Discussion by I. W. McCaig

It has long been known that the governing stability of a hydro-electric system composed of a number of generating stations is greater than that of some of its individual stations. What has not been known is the optimum method of using the system stability to stabilize governing at stations which have poor regulating characteristics.

Mr. Hovey has shown how, by adjusting the temporary speed droop and dashpot relaxation times of all the turbines of The Manitoba Hydro-Electric Board's systems to a constant value, he has obtained fast response and stable system operation.

An examination of Table 1 and Fig. 2 will show that with the temporary speed droop set at 33% and the dashpot relaxation time set at four seconds on all the governors, McArthur Falls and Pine Falls will, if operating alone, be unstable at full load. Could Mr. Hovey indicate whether there is difficulty in synchronizing units in these stations?

The paper indicates that the governor settings used in The Manitoba Hydro-Electric Board's system are slightly less than the values for optimum damping. In particular, the dashpot relaxation time T^{τ} was made equal to four times the water starting time T_{ω}, rather than the optimum value of five times. Fig. 5 shows that this shorter relaxation time causes slight over-compensation and the speed change falls to a negative value after an initially positive one. Was there some special reason for using a shorter-than-optimum dashpot relaxation time?

Author's reply

The author wishes to thank Messrs. Avery, Harland, and McCaig for their discussions of his paper.

In commenting first on Mr. Avery's discussion, he is quite correct in observing that the optimum settings do not include the system self regulation effect and as a result are conservative as far as stability is concerned.

In connection with comparing the performance of the system before and after making the adjustments, it is unfortunate that we were unable to make tests to indicate any improvement. However, we do know that the present settings do not result in any instability even if the stations become separated. Subsequent tests are, however, contemplated to compare system performance based on using the individual plant characteristics of water starting time and mechanical starting time instead of the weighted

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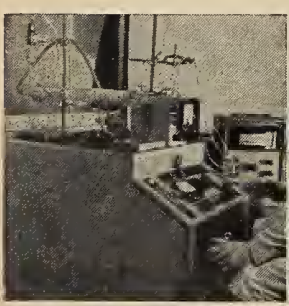

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value of these parameters as was described in the paper.

In Mr. Harland's discussion, he points out that certain individual plants, if theoretically isolated on a resistance load, would be unstable, this being particularly the case at McArthur Falls. This reasoning is quite correct. However, it is felt that if McArthur ever did become separated, the increased inertia due to load and the self regulation effect would stabilize the plant. In attempting to answer Mr. Harland's question (1) the explanation as to why McArthur is not unstable at speed no load, is that the water starting time at speed no load, is very much lower due to the lower water velocity. Also, the fact that the self regulating effect of the speed torque curve helps to stabilize the unit. The above two stabilizing influences are somewhat offset by the relative steep torque gate curve at speed no load. Therefore, the explanation for stability at speed no load, would be due to the preponderence of stabilizing effects at this operating point.

In answering question (2), we have never attempted to analyse the stabilizing synchronizing torque which must of necessity flow to hold the system at stable frequency.

Question (3). It is the intention of the author's organization to make some tests based on individual plant settings to determine if there is any improvement or otherwise in system performance as regards frequency regulation. The settings would be carried out in a similar manner as outlined in the question.

With Mr. McCaig's discussion, the author feels that the answers to some of the questions are covered above.

In answer to the last question, the optimum setting was selected to give a slightly oscillatory response for the assumptions as chosen (i.e. resistance load, no self-regulation) on the basis that with the existing self regulating effect the response would be critically damped.

DESIGN OF INDUSTRIAL GEARS

R. D. Mutch, M.E.I.C.
Product Engineer,
Dominion Bridge Company Limited, Montreal

The Engineering Journal, November 1960, page 53.

Discussion by J. B. Mantle, M.E.I.C.

As a teacher of a class in Machine Design involving gear design, I believe that the question as to what constitutes an "industrial gear" and a "precision gear" warrants some discussion. Surely an error in shape of 0.003 in. or of 0.001 in. would not effect impact loading on the teeth if the shape error was all positive or all negative! I feel that in specifying tooth errors reference should be made to surface roughness values. Perhaps Mr. Mutch could give some indication as the RMS surface roughness values that could be expected with "industrial" and with "precision" gears of ID.P. Would it not be practical for design engineers to have a more precise criteria for tooth error than that commonly employed?

A further question is related to the resulting relation between face width and diametral pitch using the design procedure recommended for spur gears. Does this come out as a constant for the usual gear or is it quite variable? I have in mind the commonly used ratio for spur gears of $F = \frac{10.}{P}$

Author's reply

The tooth profile errors are arbitrary values and have been chosen more as an approximation to suit production methods than from theoretical considerations. This was done for the precise reason that Prof. Mantle has mentioned, namely, that few criteria exist, to my knowledge, which would determine to what class a gear should be manufactured.

As tooth profile errors can occur in a random fashion, it seems necessary to take them into account when designing, as there could be no guarantee that the profile error was all positive or all negative across one tooth face or that all the mating teeth would be perfect in profile. In other words, the profile errors could be and often are, variable within the face width of any one tooth. This was demonstrated during investigations into turbine gear failures in warships and the errors were attributed to lack of rigidity in the machines used for cutting the teeth.

The question of surface finish has always been a difficult one and as Prof. Mantle points out, has a definite influence on the performance of gears. Notice is taken of this in the paper where the gear box test is described. For heavy industrial gears I would suggest that a precision gear might be specified as having a surface finish not courser than 32 micro-inches RMS and that a commercial gear would have a finish of 63 micro-inches RMS. These values represent respectively a ground surface and the finest tool-produced surface without grinding as we at Dominion Bridge Company are accustomed to work. Of course, I realise that in other classes of manufacture, these finishes might be regarded as extremely rough and, in high precision work, completely unacceptable. It would seem, therefore, that it would be necessary to establish various degrees of finish for different classes of manufacture, but the above noted finishes could probably be used as a basis for design.

The proportions of face width to diametral pitch can vary quite widely by this design method, depending on the relative values of allowable surface stress and allowable bending stress used for the material under consideration. For example, a 40% carbon steel, flame hardened, would give a relatively narrow face width for wear and a relatively course pitch for strength. However, the factor $\frac{P}{Y}$ generally allows a number of selections to be made for teeth and pitch and the final choice of these values would be guided by the designer's experience. In this respect, the method outlined in the paper may not be quite rigid but it at least determines the minimum face width necessary for the material under consideration.

With helical gears, the minimum ratio of $\frac{\text{Face width}}{\text{D.P.}}$ is determined by considerations of overlap and in such cases the method provides a check on this value and ensures that the face width is adequate for wear. EIC

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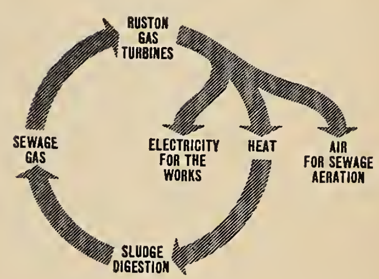

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Library Notes

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VIBRATIONS MECANIQUES, 2. ed.

Translated, presumably from the fourth English language edition, this volume is intended for both an undergraduate and graduate text, emphasizing the applications of principles and calculations to the practical vibration problems encountered by the practising engineer, It covers systems with one or more degrees of freedom; multicylinder engines; rotating machinery; self-excited vibrations; systems with variable or non-linear characteristics. (J. P. Den Hartog. Paris. Dunod, 1960. 460 p., 65 N. Fr.)

TECHNIQUE METALLOGRAPHIQUE

An introduction to metallography, describing methods of the preparation of metal surfaces for micro- and macrography. The author discusses the various methods of mechanical polishing and of electrolytic polishing; the preparation of test pieces; anodizing; pickling; the uses and methods of macrography. Examples are given of both macrographs and micrographs, taken from work done in an industrial laboratory. A bibliography is included. (A. Roos. Paris, Dunod, 1960. 121 p., 13.50 N. Fr.)

L'USINAGE DES METAUX PAR ELECTRO-EROSION

Much of the early work on the finishing of metals by electro-erosion or spark erosion was done in Eastern Europe. This translation from Polish outlines the research which has been done in Poland, and includes a chapter on recent research which was not in the original edition. The various methods of electro-erosive finishing are discussed in detail, as are the machines used. There is a bibliography, mostly of Polish and Russian articles, covering the years from 1951. (K. Albinski. Paris, Dunod, 1960. 128 p., 17 N. Fr.)

MESURE ET INSTRUMENTS DE MESURE, 4. ed.

Intended both for those who make measuring instruments, and those who use them, this text is concerned with the study of instruments, the choice of a method of measurement, and the use of the results. The first chapter defines the terms used in measuring, and lists the five important points to consider in the use of measuring instruments; extent, sensitivity, precision, acuteness and speed. The five points are discussed at length in the following chapters, while a final chapter covers the interpretation of results. (J. Idrac. Paris, Dunod, 1960. 125 p., 9 N. Fr.)

THERMODYNAMICS AND THE HEAT ENGINE

An introductory study, in which the stress is placed on the importance of the thermodynamic system and its application to the processes of energy conversion. In addition, there is a large proportion of practical description. The topics, which are presented as simply as possible, include in addition to the chapters on thermodynamics, the principles of action of heat engines, engine efficiency, reciprocating gas compressors, air standard cycles, properties of vapours, reciprocating steam engines, steam power plant and cycles, and combustion. (D. H. Marter. Toronto, Longmans, Green, 1960. 812 p., $12.60.)

THE ENGINEERING INSTITUTE LIBRARY

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Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

PHYSIQUE ET TECHNIQUE DES TUBES ELECTRONIQUES

The first volume of this work covered vacuum physics and technology. This second volume is concerned with the study and structure of electron tubes. The first part of the book discusses general principles, starting with a summary of electron physics, and including the behaviour of electrons in metals and their emission, and the behaviour of electrons in electric and magnetic fields. From this the author shows the methods of calculating the elements in the different types of tube — diodes, triodes, high frequency, cathode ray and gas.

The second part is concerned with tube construction: materials used; constituent parts; and the manufacture of cathode tubes and special electron tubes. Throughout the volume, the author is concerned more with the principles involved rather than the ultimate use of the tubes. (R. Champeix. Paris, Dunod, 1960. 427 p., 58 N. Fr.)

COPPER COSTS AND PRICES: 1870-1957

Although this study is concerned with copper, it throws light on the general run of long-run cost increases which may be used in the study of other minerals. This is particularly valuable considering the attention focused in recent years on possible future difficulties in obtaining raw materials.

Some of the topics covered by the study include the effects of unusual events on prices; investment in the mineral industry; price manipulation prior to World War I; an evaluation of competition in the industry; the cost of producing copper; copper resources, and the significance of level price over long periods. This study was sponsored by Resources for the Future. (O. C. Herfindahl. Toronto, Burns and MacEachern, 1959. 260 p., $7.00).

ELECTRICAL TECHNOLOGY

An English undergraduate text, covering the first-year electrical engineering syllabus, and including over 100 worked examples and almost 700 additional problems, with answers. The 21 chapters cover circuits; electromagnetism; electrostatics; d.c. machines; generators and motors; alternating voltage and current; symbolic notation; single-, two- and three-phase circuits; transformers; alternators; thermionics; electric lamps; measurements and accumulators. (Edward Hughes. Toronto, Longmans, Green, 1960. 694 p., $3.25.)

APPLIED MECHANICS

Particularly intended for those writing the applied mechanics examinations of the British Institutions, this volume also includes many worked examples, and

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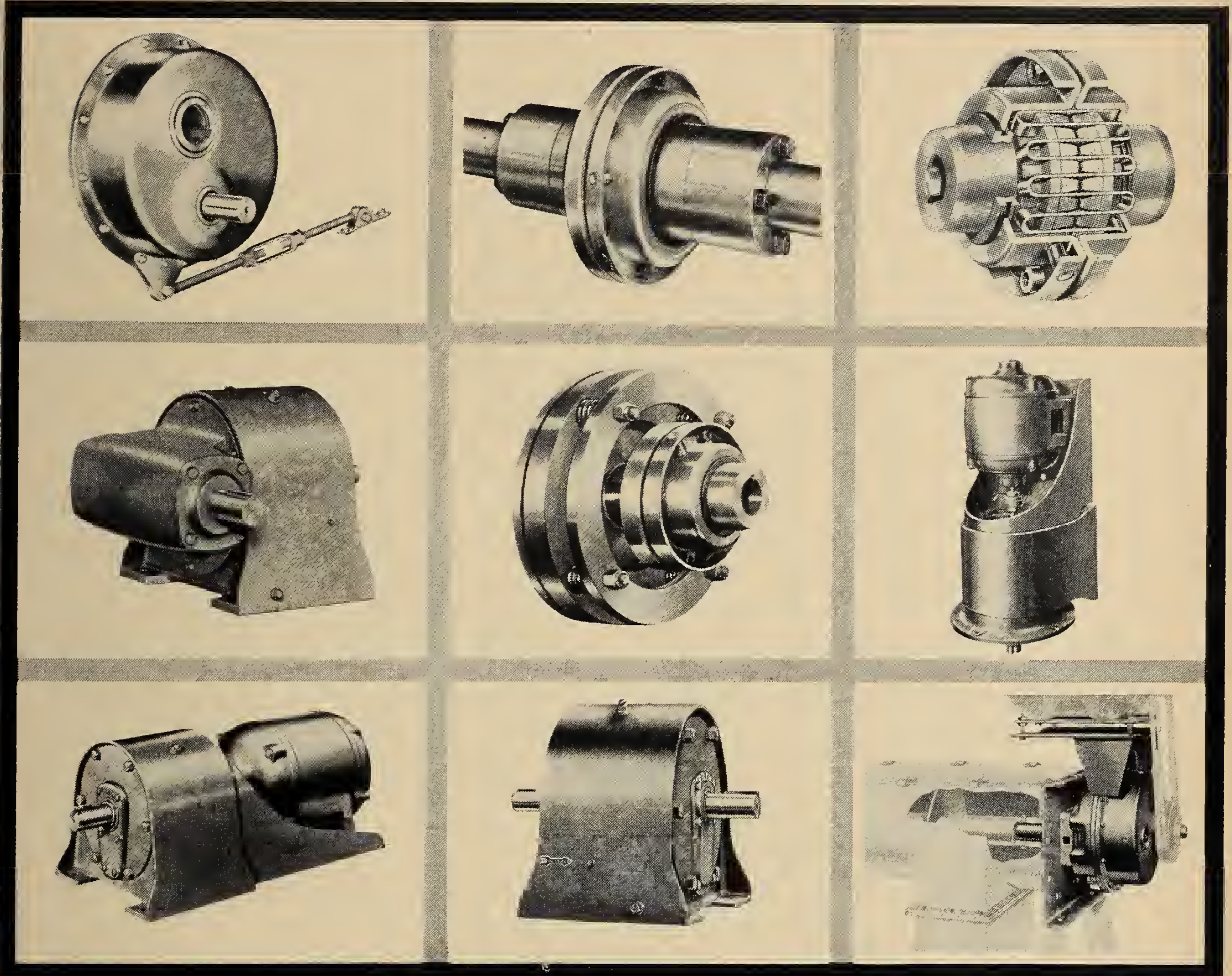

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problems and answers. The author covers statics; friction; dynamics; harmonic motion; stress and strain; bending moment; bending of beams; torsion; hydrostatics and hydrodynamics. Although this is an introductory text, the author has indicated, for those who will be continuing their studies, the way in which the subjects develop in later stages. (P. D. Collins. Toronto, Longmans, Green, 1960. 347 p., $3.25.)

HEAT ENGINES

Another first text on heat engines, with less emphasis on the thermodynamic background, and more description and discussion of the various engines. The first chapters cover gases, thermodynamic reversibility and ideal thermal efficiency, entropy, and ideal engine cycles using gases. Following chapters deal with internal combustion engines; steam, and the steam plant; the steam engine; steam turbines; engine trials, combustion; heat transfer and thermometry. Many worked examples are included, as are problems with their answers. (Rayner Joel. Toronto, Longmans, Green, 1959. 531 p., $3.25.)

CONSTRUCTION DU NAVIRE DE COMMERCE

A useful study of the construction of merchant ships intended for those who sail them rather than those who build them.

An introductory section gives general information on different types of vessels, tonnage, definitions of nautical terms, strength of materials and fatigue, and includes a very useful chapter on the provisions of the various international conventions governing safety at sea. The second section is concerned with the actual construction; materials, standards, the different parts of a vessel, hull, paint and fittings, accommodation, piping, ventilation, electrical installations, etc. The third section covers various stages of construction, drawing up plans, laying the keel, launching etc., and inspection of the vessel in service. (E. Chicot. Paris, Editions Maritimes et Coloniales, 1960. 423 p., 32 N. Fr.)

ACCELERATEURS DE PARTICULES ET PROGRES SCIENTIFIQUE

A relatively non-technical account of the principles of operation of particle accelerators and their scientific importance. It discusses the first experiments with accelerators, the invention of the cyclotron, high speed accelerators, and large accelerators. It classifies the accelerators at present in use, and describes them. (N. Felici. Paris, Dunod, 1960. 161 p., 12.50 N. Fr.)

INTRODUCTION A L'ETUDE DE LA RHEOLOGIE

The increasingly high temperatures to which metals are being subjected, the general use of plastics and rubber, and the great precision required of the mechanical engineer, means that the classical strength of materials theories are often not sufficient. Rheology, the study of the flow of matter, is therefore of interest both to industry and science.

The first five chapters of this text are concerned with basic theories and terminology. The second section of the volume considers different materials and their properties: metals and the theory of dislocations; glass; plastics; rubber; paint and varnish; gasoline. Three final chapters discuss the importance and applications of rheology in biology, soil mechanics, and geology.

Each chapter is written by an expert in the field. (Ed. by B. Persoz. Paris, Dunod, 1960. 251 p., 44 N. Fr.)

METHODES MODERNES D'ETUDE DES SYSTEMES ASSERVIS

A review of recent progress in servomechanisms, especially theories which have been developed since 1951.

The first section is concerned with linear systems, particularly poles and zeros and the s plane. The second section discusses the statistical study of servo systems, random input, Wiener's method, etc. The third section considers the extensions of linear methods, systems with several variables, frequency response, and pulse systems. The final section reviews non-linear servo systems, particularly the work on them being done in Russia, and covers the Kochenburger, or describing-function approach, the phase plane, on-off systems, general methods of non-linear mechanics, non-linear stability, and the theories of Poincare and Ljapunov. There is a bibliography, and a useful glossary, in five languages, of the terms used in servomechanisms. (J. C. Gille and others. Paris, Dunod, 1960. 460 p., 64 N. Fr.)

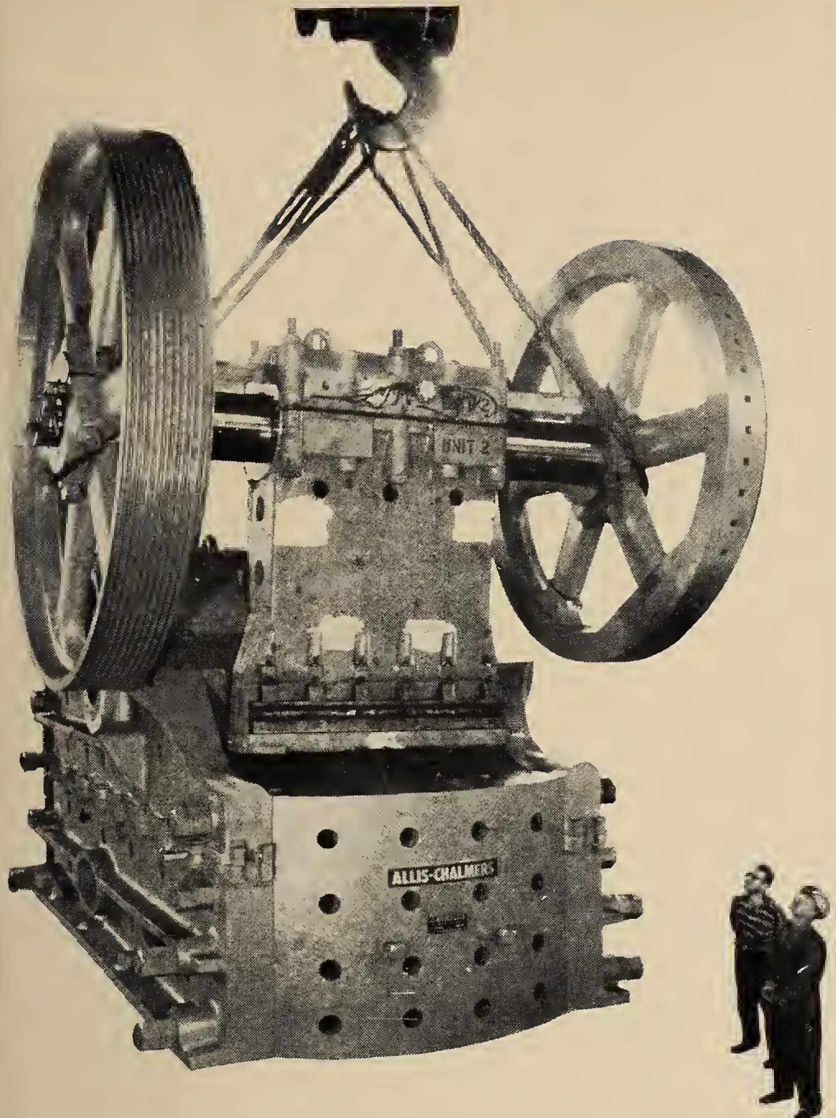
LOGIQUE GENERALE DES SYSTEMS ET DES EFFETS

In addition to discussing quadripoles and servomechanisms, the author attempts to present a picture of the whole field of servomechanism and information theory. He gives his ideas on a "physics of effects", the principle being that a system should be studied according to its logical structure, and not its material constitution. Some of the topics covered include impedance, connected systems, transmission, active systems, non-linear systems, and energy and information. (A. Ducrocq. Paris, Dunod, 1960. 298 p., 48 N. Fr.)

CHEMICAL PERIODICITY

A text book on inorganic chemistry, emphasizing the unity of the subject, by examining closely what is already known, studying the relationships among the elements, and trying to recognize the underlying reasons.

The topics covered include: the periodic law; chemical combinations; the condition of combined atoms; principles of co-ordination chemistry; physical nature of the elements; binary compounds of oxygen, hydrogen, nitrogen, sulphur, fluorine, chlorine, bromine and iodine; inner transition elements; and the period-



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- Lowphos Iron Mines Ltd., Capreol, Ont.
  Two 584 HYDROCONE*
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- Marmoraton Mining Co. Ltd., Marmora, Ont.
  One 584 HYDROCONE*
- Nimpkish Iron Mines Ltd., Beaver Cover, B.C.
  One 851 HYDROCONE*
- Quebec Cartier Mining Corporation, Lac Jeannine, Quebec.
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icity of coordination chemistry. Many periodic charts are included, as are references for further reading. (R. T. Sanderson. New York, Reinhold, 1960. 330 p., $11.75.)

MARINE DIESEL ENGINES, 2nd. ed.

Since 1952 when the first edition of this book appeared, there has been a change in marine heavy oil engine practice from atmospheric induction to pressure induction. This change is reflected in the text. The book is intended primarily for marine engineers, and deals with propulsion machinery at present in service.

After two introductory chapters dealing with elementary theory and pressure-charging, there are chapters on the engines manufactured by eight British and European companies, written for the most part by those connected with the companies. The remaining chapters cover various topics and problems the author has discussed with marine engineers, including chemistry of combustion; crankcase explosions; creeping cracks; rating of engines; and engine performance. The author is well-known for his other books on marine diesel engines. (C. C. Pounder. London, Newnes, 1960. 692 p., 70/-.)

ELEMENTARY ENGINEERING MECHANICS

Intended primarily for a two-year technician programme this text requires only a basic knowledge of algebra and plane geometry. It describes the essential elements of statics and dynamics, and their application to engineering problems. The author stresses fundamental concepts, and shows how complicated problems can be solved by correct analysis. (E. G. Key. New York, Wiley, 1960. 457 p., $5.50.)

HEAT TRANSFER

An undergraduate or graduate text, presenting the fundamental concepts, and showing how the mathematically derived results can be used to gain an understanding of heat transfer processes. Conduction, convection and radiation are all discussed, and the topics under which they are covered include steady state heat conduction in one dimension, extended surfaces, viscous fluid motion; boundary layer theory; forced and free convection; combined conduction and convection. Problems and references for further reading are included. (A. J. Chapman. Galt, Brett-MacMillan, 1960. 452 p., $9.00.)

EXHIBITION AND DISPLAY

This well-produced volume studies the three activities which are the object of any exhibit — to explain, to create atmosphere, and to sell. They cover store displays, industrial and government exhibits, and large international trade fairs and expositions. The principles of good display are considered, and attention is paid to circulation, the eye, lighting, special effects and plants. The practice of these principles is discussed in relation to the various types of exhibit. The text is illustrated with more than 350 photographs and line drawings.

Both authors are experienced in the exhibit field. Mr. Gardner's projects include the British Pavilion at the 1958 Brussels Fair, and the 1951 South Bank Exhibition in London. (James Gardner and Caroline Heller. New York, Dodge, 1960. 192 p., $13.75.)

PROBLEMES DE GESTION D'ENTERPRISE, 3 ed.

A discussion of some of the problems faced in the operation of a business, commencing with a consideration of the administrative structure, with examples taken from factories and retail stores with several branches. Succeeding chapters cover the planning of production, budget, financing, the uses of publicity and the uses of operations research in the organization. (M. Bourquin. Paris, Dunod, 1960. 222 p., 27.60 N. Fr.)

*VERS LA MAITRISE DE LA FUSION THERMONUCLEAIRE: PROJET SHERWOOD

A French translation of the first unclassified report on the controlled thermonuclear effort in the United States. Beginning with the basic principles involved in a fusion reaction, it continues with the various methods now being studied to control thermonuclear energy with the hope of eventually producing net power. Methods such as pinch, stellarator, magnetic mirror, and molecular ion ignition are explained. (A. S. Bishop. Paris, Dunod, 1960. 199 p., 39 N Fr.)

*FILES D'ATTENTE STOCKS ET ENTRETIEN

Translated from the U.S. publication, Queues, inventories and maintenance, this is an introductory monograph to the subject of queuing problems and discusses the effect of change of arrival and service distributions on queuing results. Queuing problems are dealt with from the standpoint of the Kolmogorov equations relating the probabilities, and specific applications such as those relating to repair and maintenance of machinery are analyzed and solved. (P. M. Morse. Paris, Dunod, 1960. 205 p., 33 N. Fr.)

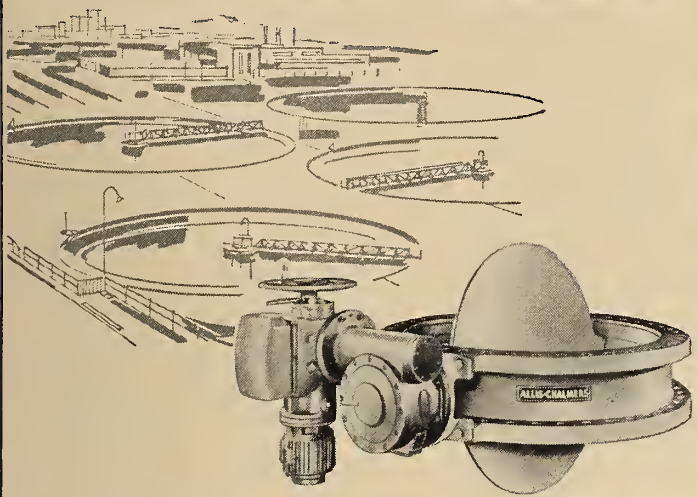
PROGRAMMATION DES CALCULATRICES NUMERIQUES

A translation of one of a series written by Generel Electric authors on various aspects of engineering practice, this volume provides an introduction to the field of computer programming, emphasizing basic principles applicable to all computers. The author discusses the elements of a computer, and their relationships, and gives information on coding, binary and octal number system, and decimal point location methods.

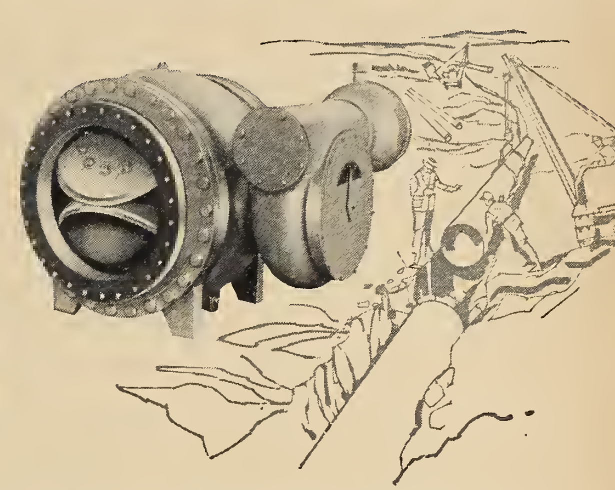
The principles of programming are given with examples and explanations, and application to a representative computer. The original bibliography is included, with a notation when a French translation is available. (D. D. McCracken. Paris, Dunod, 1960. 255 p., 36 N. Fr.)

CANADIAN

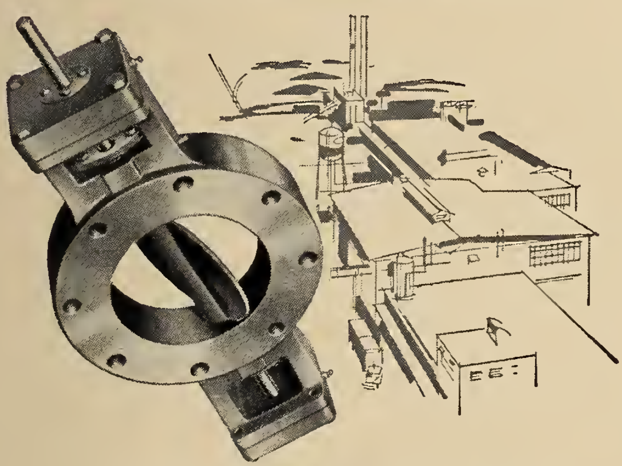
ALLIS-CHALMERS



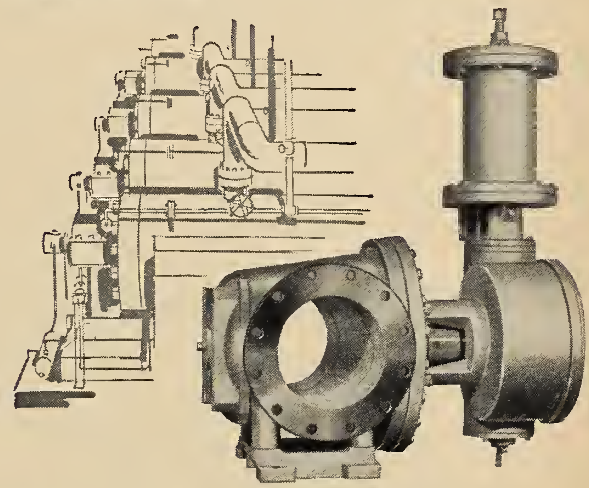
BUTTERFLY VALVES — For liquids or gases — uniform control in all positions, fast positive regulation and closure, minimum pressure drop. Compact and lightweight. Sizes from 1 in.



BALL VALVES — Easy manual shutoff under adverse conditions. Slight wedging action gives unusually drop-tight closure. Sizes: 12 to 48 in.



WAFER VALVES — A new design of butterfly valves with space-saving flexibility, suited to most any type of operation. Sizes from 3 to 36 in., including high-pressure types.



ROTOVALVE — A cone valve suited to virtually any type of operation or location. Offers the least pressure loss, greatest initial shutoff, controlled closing time, positive seating.

Now: for power plants, sewage and water works —

a full line of rotary valves

Serving you even better through a broader line — Allis-Chalmers offers the finest in butterfly, ball and cone valves for industrial applications, power plants, sewage and water works. Also available are complete valving systems in standardized "packages" that provide *remote, telemetered control of valve operation.* These additions further round out Allis-Chalmers line that includes Angle, Needle, Relief valves, sleeve-type values and accumulator systems. *For complete information, contact your nearest A-C Sales Office or write direct to* **Canadian Allis-Chalmers Limited,** P.O. Box 37, Montreal, Que.

Rotovalve is an Allis-Chalmers trademark.

60P4

ELECTRICITY AND MAGNETISM

An intermediate undergraduate text for students having a knowledge of general physics and calculus; and just beginning the study of differential equations. The author has presented his material as clearly and concisely as possible, and where applicable, has related the topics to atomic, nuclear and solid state physics. The topics covered include electric forces and electric fields; capacitance; dielectric theory and behaviour; resistance; thermoelectricity; moving charges and magnetic fields; electromagnetic induction; magnetic properties of matter; galvanometers; etc., transient and alternating currents. The author is professor of physics at McMaster University. (H. E. Duckworth. Toronto, Macmillan, 1960. 424 p., $7.00.)

BASICS OF INDUCTION HEATING

The fundamental principles of induction heating, presented in the familiar Rider "pictured-text" manner. The electrical and thermal aspects are covered, as are mechanical problems, and the various uses of induction heating in manufacturing. The author has worked in the field of induction heating for many years. (C. A. Tudbury. New York, Rider, 1960. 2 vols., each $3.90.)

BASIC CARRIER TELEPHONY

Another in the "pictured-text" series, this volume is concerned with the principles and methods of carrying multiple telephone conversations, etc., over one wire or cable, or radio circuit. It covers telephone carrier definitions and fundamentals, circuitry, modulators, controls, switching, system operations, cable carrier systems, and carrier applications to radio systems. (David Talley. New York, Rider, 1960. 170 p., $4.25.)

WIRE REINFORCEMENT INSTITUTE BUILDING DESIGN HANDBOOK

The first section of this Handbook contains general information and illustrations on the use of steel wire fabric in reinforced concrete construction. The second section, Design, is concerned primarily with the increasing use of heavy welded wire fabric, and as it consists mostly of a series of design tables, should prove a useful working tool. Tables are included for one-way slabs, with spans up to 24 feet, two-way flat slabs, tilt-up wall panels, vertically spanned basement walls, cantilevered retaining walls, and square individual column footings. A.S.T.M. specifications for welded wire fabric are included. (Washington, Wire Reinforcement Institute, 1960. 168 p., $3.00.)

MOBILE MANUAL FOR RADIO AMATEURS, 2nd ed.

Over 80 articles on amateur mobile operation which have appeared in the League's periodical, QST, including articles on the construction of receiving converters, transmitters, antennas, power supplies, and the suppression of noise in vehicles. Also included for the first time are articles on emergency and portable equipment. (West Hartford, Conn., the League, 1960. 282 p., $3.00.)

SOLID PROPELLANT ROCKETS

The Princeton University Press has decided to issue in paperback form sections of its valuable series, High Speed Aerodynamics and Jet Propulsion, in order to make them more easily available to students and research engineers. The books are prepared from the original plates. The first section of this volume covers the combustion of solid propellants. The second section is concerned with the rockets themselves, construction; interior ballistics theory; composition, preparation and properties of propellants; motor design; and development trends. (Clayton Huggett and others. Toronto, Saunders, 1960. 167 p., $2.45.)

ENGLISH DUDEN: A PICTORIAL DICTIONARY, REV. ED.

This is a different type of dictionary. The 25,000 objects it illustrates are divided, by subject, into 368 sections, for each of which there are illustrations, some in colour, and word lists in English. The subjects are in nine main divisions, ranging from atoms through

(Continued on page 184)

MOVED RECENTLY?

HAVE YOU NOTIFIED THE CIRCULATION DEPARTMENT?

YOU CAN HELP THE EMPLOYMENT SERVICE

Hundreds of communications are made yearly between employer and employee through the classified advertisements in The Engineering Journal and Employment Service Bulletin.

In order to give you both better service, we rely on your co-operation.

Employers: Acknowledge all applications received in answer to "The Vacancy" you advertise.

Employees: Acknowledge all applications received in answer to "The Situation Wanted" you advertise.

Courteous, prompt replies cost you little—and they pay often handsome dividends.

UNIVERSITY GRADUATE ELECTRICAL ENGINEER

LOCATION: Sept Iles, Quebec, but required to travel for short periods for field work.

QUALIFICATIONS: At least two years field experience in any branch of electrical power generation, transmission and distribution, preferably with a power utility.

DUTIES: Work involves trouble shooting, records and statistics, system studies, and general assistance in the operation and maintenance of private hydro-electric power systems, plus design of new work and extensions.

Salary commensurate with experience.

Please reply in confidence stating age, education, resume of work experience and references.

IRON ORE COMPANY
OF CANADA
Personnel Department
810 Cote de Liesse Road
Montreal 9, P.Q.

recent graduate in electrical engineering. This position offers a young engineer an excellent opportunity to familiarize himself with industrial applications of both A.C. and D.C. equipment. We also generate part of our own power requirements by means of both hydraulic and steam driven alternators. Good opportunities for advancement. Apply in writing to File No. 7015-V.

ELECTRICAL ENGINEER. Established base metal mining company in Ontario requires the services of a graduate electrical engineer with experience in industrial and power distribution systems. Applicant will be required to design and produce the drawings for the power distribution of a mining plant presently in the engineering stage. Property is in vicinity of medium sized city offering all amenities for family living. File No. 7131-V.

ELECTRICAL MAINTENANCE ENGINEER. Electrical Engineer who has graduated in the last ten years, with three to five years experience, to work in the Electrical Department of a large diversified paper mill in Eastern Ontario. Experience in pulp and paper preferred, with an interest in electronics and controls. Apply in confidence with complete resume and salary requirements to File No. 7148-V.

MISCELLANEOUS

ENGINEERS FOR SALES, project, design, research, development, control and management. Graduates of all types and ages required by clients of The Technical Service Council, a non-profit industry sponsored placement service. Write 2 Homewood Avenue, Toronto 5 for applications. There is no charge for work done on your behalf. File No. 6648-V.

SALES ENGINEER. The company, a well known manufacturer of centrifugal pumps with head office in Toronto, requires recent graduates for its Montreal and Toronto Sales Offices. After a short training period, the successful candidates will be engaged in outside sales work, calling on refineries, chemical plants, major contractors, consulting engineers and the pulp and paper industry. Reply giving full particulars to File No. 7001-V.

ASSISTANT PROFESSOR required for teaching and research in hydraulics and fluid mechanics. Salary $6000 to $8000 depending on qualifications. Please submit full details with application to President, Nova Scotia Technical College, Halifax, Nova Scotia. File No. 7072-V.

SALES ENGINEERS: With B.Sc. Mechanical or Chemical required by fully integrated major oil company, marketing department, for early assignment in Western Canada. If you believe SALES is a true engineering function, then your future professional life can fit this position. Training course given. Excellent remuneration and advancement prospects. Three to five years' sales etxperience desirable but not a requirement. Knowledge of modern industrial equipment a definite asset. Permanent position. Full company benefits. Please give personal history and statistics. File No. 7128-V.

GRADUATE ENGINEER to supervise quarry and lime plant operations in Manitoba. Mining degree desirable but Chemical or mechanical degree with experience in open pit mining or production techniques would qualify. Some construction experience would also be helpful. The successful candidate will be responsible for operating and modernizing two separate quarrying and production plants and would live on location for two to three years. At that time it is hoped he could then accept wider responsibilities and probably reside in Winnipeg. Salary commensurate with qualifications, experience and established ability. Employment benefits include pension, insurance and medical. Please reply by confidential letter stating fully personal experience, academic background and on-the-job experience. File No. 7135V.

CITY OF TORONTO PLANNING BOARD. Applications are invited for the following positions: 2 City Planners Grade II. Salary: $5314 - $6201 per annum. FUNCTIONS: To assist in the preparation of surveys, detailed designs and reports for immediate redevelopment proposals. To analyse and report on road proposals. QUALIFICATIONS: Training and/or experience in planning and physical design. Apply in writing to the Commissioner of Planning, City of Toronto Planning Board, 129 Adelaide Street West, Toronto, Ontario, giving details of experience, qualifications and references. File No. 7142-V.

ENGINEER REQUIRED

Salary Range — $12,000

"The Canadian Association of Broadcasters" requires qualified professional engineer, to locate in Ottawa. Person selected will have, preferably, qualifications recognized by Department of Transport Standards. Send full details in writing to: Post Office Box 627, Station "B", Ottawa.

The City of Prince Albert, Saskatchewan, (pop. 22,000), requires an assistant to the City Engineer.

Duties: to assist in all phases of Municipal projects and operation of the department, with emphosis on the water and sewer systems. Qualifications: Must hold a degree in Engineering preferably Civil from a recognized University.

Position offers varied experience, future security and an opportunity for advancement.

Starting salary $400.00 to $450.00 per month depending on experience.

Apply in writing stating age, experience and relevant information to the undersigned.

S. E. Parker,
Personnel Officer,
Prince Albert, Saskatchewan.

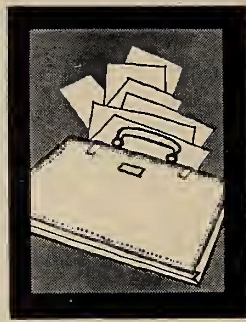
JUNIOR ENGINEERS

required for
Dept. of Lands & Forests
B.C. CIVIL SERVICE

Starting salary $400 to $430, rising to $510 per month. Challenging positions are available in the forest development road program with opportunities for diversified training and advancement within the Department. Applicants must be Canadian citizens or British subjects with graduation in civil or forest engineering. Consideration will also be given to graduates in mechanical or agricultural engineering. For application forms apply IMMEDIATELY to The Chairman, B.C. Civil Service Commission, 544 Michigan Street, Victoria, B.C.

COMPETITION NO. 60:140A.

Business and Industrial Briefs



Appointments and Transfers

Four executive appointments and the addition of three engineers to the staff of its plastics division have been announced by Du Pont of Canada. Three new vice-presidents have been appointed. They are: **Frank S. Capon**, a director since 1957 and treasurer since 1949; **F. G. Raymant**, manager of the textile fibres department; and **H. F. Hoerig**, manager of the research and development department since 1954. Vice-president **R. G. Beck** simultaneously assumes the position of executive vice-president. **A. J. Houston**, an electrical engineer, and **P. A. Turner**, a chemical engineer formerly with the company's petroleum and chemicals section, join the market development section in Montreal. **W. A. Cooksey**, a mechanical engineer, becomes a sales representative in Toronto.

J. C. Cochran has been appointed vice-president and general manager of Murray-Brantford Limited.

The appointment of **C. F. Smith** as Assistant Manager, Advertising and Sales Promotion, Union Carbide Canada Limited, Linde Gases Division, has been announced.

Ross E. Magnus has been appointed Manager of Sales to Equipment Manuacturers for Canadian General Electric's Electronic Tube Section.

Stoody Company of Whittier, Calif. has recently appointed **Max Cadonoff** field representative for Eastern Canada. He will work with the Stoody distributor, Air Reduction Canada Limited in Ontario, Quebec and the Maritime Provinces.

James Kenneth Latta recently joined the Division of Building Research, Construction Section, National Research Council, Ottawa.

A new company FORESTAL, Forestry and Engineering Limited of Vancouver has been formed. The new executive officers are: **Ian C. MacQueen**, President; **J. R. Collins**, **E. S. Reid** and **Cedric W. Walker**, Vice-Presidents.

Thomas Crooks is the new Vice-President, Industrial Sales, of Empire-Hanna Coal Division, The M. A. Hanna Company of Toronto.

James A. Richardson, Vice-President of James Richardson Sons, Limited has been elected a director of The International Nickel Company of Canada Limited.

William M. Hewat has been appointed western district manager for Naugatuck Chemicals, Division of Dominion Rubber Company Limited.

F. H. Van Dyk has been appointed manufacturers' agent for York-Shipley of Canada in London, Ont.

A. D. Ross & Company Limited, subsidiary of The Foundation Company of Canada Limited, has elected **S. J. Spall** a director and appointed him Vice-President and General Manager.

James R. Kleisle has been named a plant equipment sales representative for Corning Glass Works of Canada Ltd., Leaside, Ont.

Developments

Information contained in this section has been culled from press releases. Products and services do not carry the endorsement of the Institute.

TWO GRATE-KILN SYSTEMS successfully operated at the Humboldt Mining Company have confirmed the feasibility of producing higher-quality iron ore pellets from low-grade ore deposits. Located near Ishpeming, Mich., the Humboldt plant is the first installation of the Grate-Kiln system applied to iron ore agglomeration.

THE PERFO METHOD of roof bolting reduces the risk of slippage and eliminates any point of concentrated stress. This method is based on hollow perforated steel pipes cut longitudinally and filled with plastic mortar. The halves are tied together and placed in a drilled hole. A reinforcing bar then is driven into the sleeve, expanding the mortar to fill the hole completely.

THE FIRST CANADIAN installation of Koroseal lining to concrete was completed recently by B. F. Goodrich Canada Limited at the Waterloo, Ont., sewage disposal plant. Applied to two tanks carrying ferric chloride the lining guards against tank seepage. This is an absolute necessity as two walls of the tank also are building walls.

PORTABLE LIGHTING SYSTEMS for many uses can be assembled quickly from industrial lighting components produced by the Joy Manufacturing Company (Canada) Limited. Bulletin B76 illustrates how such lamps, extensions, sockets and other unitized assemblies can be connected to form an economical lighting system which is, in effect, custom tailored to individual requirements.

NITROGEN was used recently to purge a new, 4,750-yard long steel gas main in the United Kingdom. The main has a 24-inch diameter. The object of the operation on the all-welded pipe was to purge the main of air to remove the danger of an explosive air-gas mixture during introduction of gas into the main at a later date.

A NEW NAME has been adopted by the Formed Steel Tube Institute. The Institute, which represents more than 20 leading manufacturers of welded steel tubing, now is called the Welded Steel Tube Institute. A non-profit organization with headquarters in Cleveland, the Institute was established to encourage research and development, foster efficient production, inform member firms of technical advances in the industry, and explore new markets and product applications.

FOUR RUSSIAN TECHNICAL journals, translated into English, will be published during 1961 by the Instrument Society of America, under a grant from the United States National Science Foundation. The 1960 issues to be published are Automation and Remote Control, Measurement Techniques, Instruments and Experimental Techniques, and Industrial Laboratory.

THE SALE in the United States of phosphatic fertilizers produced by the Electric Reduction Company of Canada, Ltd., Toronto will be made through the Agricultural Chemicals Division of Inter-

national Minerals and Chemicals Corporation, Skokie, Ill. Announcement of the agreement was made recently by the presidents of the two companies. ERCO now is building a large phosphatic fertilizer plant at Port Maitland, Ont. Production is scheduled to start early in 1961.

CONCRETE for stadiums and auditoriums is discussed in a publication released by the Master Builders Company, Ltd. Problems encountered and solved in the construction of 16 major stadium and auditorium projects are explained. Included are case histories concerning the Dallas Memorial with its lightweight roof design, the placing of the reinforced concrete dome roof of the Albuquerque Civic Auditorium, and the thin shell concrete roof design at the University of Cincinnati Armory.

SMITH AND LOVELESS COMPANY is the new division formed recently by Products Tank Line of Canada, Ltd. The new division will manufacture in Canada a complete line of factory-built sewage lift stations and sewage treatment plants. The units will be manufactured at the Oakville, Ont., plant of Sparling Tank and Mg. Co.

FINAL BALANCING of automotive engines, a production problem in the Canadian automotive industry, can be accomplished with a special purpose machine designed and built by Standard-Modern Tool Co. Ltd. The machine represents a distinctive Canadian approach to the problem of limited production. It employs two milling heads and a spot welding arrangement and is capable of handling both passenger and truck engines with and without torque converter equipment.

A CORPORATE NAME CHANGE to Rex Chainbelt (Canada) Ltd., by Chain Belt (Canada) Ltd. of Toronto has been announced. The Toronto firm is the Canadian subsidiary of Chain Belt Company, Milwaukee.

THREE NEW PUBLICATIONS have been released by Canadian General Electric Company. GED-4092 describes electric G-E furnaces for stress relieving and annealing large parts or heavy loads with uniform temperature distribution, greater production and lower operating costs. Bulletin GEZ-3025 includes ratings and typical applications for the new G-E industrial mass flowmeter. The third bulletin, RTV-11, describes product and application data on the complete family of room temperature vulcanizing silicone rubber compounds.

A NEW COURSE, "Principles of Semiconductor-Transistor Circuits," is being offered by International Correspondence Schools Canadian, Limited. The course is designed to meet the needs of engineers and technicians who seek training in electronics.

TECHNICAL PUBLICATIONS prepared by certain companies of the Royal Dutch/Shell Group are listed in a catalogue recently distributed. The catalogue lists 142 significant technical publications including chemical engineering, pure and applied mathematics, and pollution.

AN EIGHT-PAGE BROCHURE entitled "GM Diesel Generator Sets for Standby and Continuous Off the Line Power" has been released by General Motors Diesel Limited. The publication contains charts showing technical data regarding generator sets from 13.5 kw. to 260 kw.

INTRODUCTION TO STRUCTURAL MECHANICS, a new textbook, has been written by Paul Anderson, professor of structural engineering, University of Minnesota, and Gene M. Nordby, head of the Department of Civil Engineering, University of Arizona. Chapters on basic theory have been designed to apply to aircraft structures and machine design as well as to traditional structures such as roof trusses, railway bridges, and highway bridges.

A SOLVENTLESS SILICONE RESIN for high temperature insulation now is commercially available, it has been announced by Union Carbide Canada Limited, Bakelite Division. Formerly it was marketed under the experimental designation Y-2090.

• MORE BRIEFS

A PIGEON-HOLE BAR RACK of new design has been manufactured by Service Steel & Engineering Ltd., Hamilton. The rack can be erected quickly from ?solidly-welded frames and brace assemblies. The brace assemblies are built in varying lengths and the pigeon holes are fabricated in a wide range of sizes. It will carry more than 150 tons of 20-foot bars.

WELDED COLUMNS for the 32-storey C-I-L House in Montreal now are being fabricated in the Lachine shops of the Dominion Bridge Company. These columns, the biggest and heaviest ever built in Canada, will be part of the tallest welded rigid frame building in the Commonwealth.

A NEW PIPE-TURNING MECHANISM has extended the life of taconite tailings pipe and speeded turning operations. Because of rapid abrasive wear on tailings pipes, most taconite plants turn pipes periodically so the pipe wears longer and at a more even rate. One advantage of the new mechanism, developed by Lake Shore, Inc., Iron Mountain, Mich., is that pipes may be turned at one-quarter turn increments rather than the usual one-third turn. This gives four pipe-wearing surfaces rather than three.

THE HIGHWAY RESEARCH BOARD of the United States has released four more publications dealing with its findings on road research. Bulletin 249 deals with the surveying and planning of highway projects and needs. No. 250 discusses pavement performance concepts. Asphaltic concrete construction is dealt with on the basis of field and laboratory studies in Bulletin 251. The fourth publication, No. 252, is entitled "Snow and Ice Control with Chemicals and Abrasives."

PLAIN FORGETFULNESS is one of the bugbears eliminated in a new battery-run clock made in England by Robert Pringle and Sons Ltd. Some models run for one year on an ordinary flashlight battery. Other models are designed to run for three to five years without attention with transistors being used in these to store energy for boosting the battery. In effect the batteries give an impulse to the clock movement every two minutes.

A COMPLETE LINE of hydraulic products for the industrial, marine and ordnance fields is presented in a 74-page catalogue distributed by Vickers-Sperry of Canada, Ltd., Division of Vickers Incorporated. Catalogue 50001C introduces new equipment in addition to information on standard Vickers products.

ONE PANEL SYSTEM of house prefabrication has attained a dominant position in housing in Canada's far north. The unusual economics and logistics of far northern building have favored the acceptance of stressed skin plywood systems during the past 13 years. The oldest northern stressed skin units have shown little deterioration after long, hard use. A review of this system is available from the Division of Building Research, National Research Council.

THE WINNIPEG OFFICES of Canadian Industries Limited have been brought under one roof. C-I-L offices formerly in the Somerset Building have been moved to the expanded Midland Street facilities where the company has had offices and a warehouse since 1941.

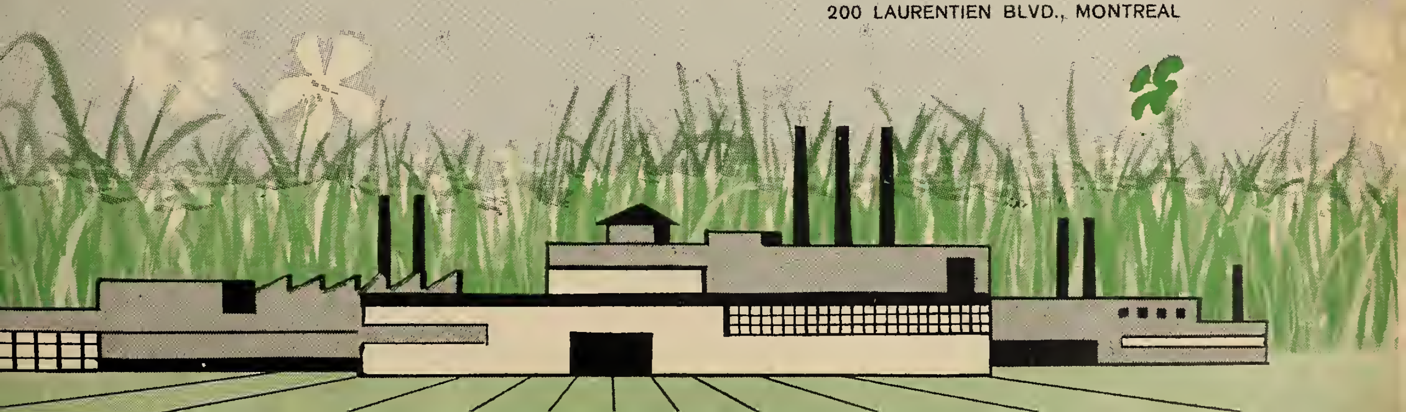
MONTREAL LOCOMOTIVE WORKS, Limited, has concluded an agreement to manufacture and sell in Canada the products of North America's largest exclusive pump manufacturer. The agreement has been made with Goulds Pumps, Inc., of Seneca Falls, N.Y. and the pumps will be marketed in Canada under the trade name "MLW-Goulds."

A CENTRAL HEADQUARTERS for the Ontario business operations of Canadian Industries Limited has been established in a new 14-storey office building in Toronto. Initially, C-I-L will occupy two floors in the building under a long-term lease.

THE FIRST TWO of four axial flow pumps, Canada's largest, have been shipped from the Lachine, Que., plant of Canadian Allis-Chalmers. Destined for use as condenser circulating water pumps at Ontario Hydro's Lakeview generating station, the four units have a 90 in. suction and a 60 in. discharge axial flow with a nominal rating of 100,000 USgpm.

THE CALGARY BRANCH of Dominion Bridge Company, Limited, has completed what its engineers describe as one of the most challenging platework projects ever undertaken by the company—the fabrication and erection of a 1,600 ft. long, 6 in. steel penstock for the latest Spray development extension of Calgary Power Limited near Canmore, Alta.

EXCEPTIONAL FREQUENCY RESPONSE, wide proportional band, low air consumption and temperature stability are characteristics of a new A/D (Advanced Design) Indicating Pneumatic Controller produced by the Bristol Company of Canada Limited. The unit can be used with any of the standard Bristol precision measuring elements for pressure, temperature and flow. EIC



• LIBRARY NOTES

(Continued from page 168)

industry, government, agriculture, transport, finance, science and religion to animals, hunting, the home and music. There is an English index and a German index. The dictionary is primarily of use for translation from German to English, but as the illustrations are the same as in the original German edition, the two volumes used in conjunction would be an excellent aid to translators, or those wishing to learn German.

In this edition, the scientific and technical vocabulary has been brought up to date—nuclear submarines, rockets, satellites, nuclear reactors, etc. — and many American terms included. (Toronto, Clarke, Irwin, 1960. 928 p., $6.50.)

PLASTIC PROGRESS, 1959

The papers presented at the 1959 International Plastics Convention are contained in this volume, together with the discussion on them. They include reports on polypropylene, epoxides, crosslinking of thermoplastics, block and graft copolymers, expanded plastics, and extrusion. There are also reports on recent developments in glass reinforced plastics in Europe, the United Kingdom and the U.S.A. (Ed. by Philip Morgan. Toronto, B.B.S., 1960. 216 p., $13.00.)

LEARNING TO STUDY

Intended primarily for college students who realize they need to cultivate efficient study habits, this text progresses from the broad concepts of learning to more specific areas of skill and knowledge. It first considers the obstacles to effective study, and goes on to discuss concentration, reading, memory examinations, notemaking, vocabulary and report writing. Campus resources for study are suggested, and lists of references for further reading are included. As this is a paperback book, intended for students, it seems unfortunate that it is so expensive. (W. W. Farquhar and others. New York, Ronald, 1960. 243 p., $8.00.)

ENGINEERING MATHEMATICS

Covering the mathematics needed for a degree, this volume is based on Dr. Blakey's University Mathematics, with the more theoretical chapters removed and replaced by chapters on the numerical solution of equations, statistics, relaxation methods, and the Laplace transformation. Other topics covered include limits, differentiation, integration, determinants, conic sections, differential equations, spherical trigonometry, moments of inertia and damped simple harmonic motion. Problems are included, together with their solutions. (J. Blakey and M. Hutton. London, Blackie, 1960. 603 p., 40/-.)

AMPLIFICATEURS MAGNETIQUES

Translated from the 1955 U.S. edition, this volume is another in the series written by General Electric authors. It discusses static magnetic amplifiers, particularly single-phase. The topics covered include the theory of magnetism; characteristics of magnetic materials; magnetic testing; saturable reactor manufacture; properties of metallic rectifiers; peaking transformers; and the applications of magnetic amplifiers. (H. F. Storm. Paris, Dunod, 1960. 560 p., 79 N. Fr.)

THEORIE ET PRATIQUE DES CIRCUITS DE L'ELECTRONIQUE ET DES AMPLIFICATEURS, 4. ed.

The first volume of this new edition discusses the theory of calculus with imaginary components, and its application to the calculation of fundamental circuits for radio and amplifiers, and for electronic circuits in general.

The second volume considers the use of electronic circuits for transmitters and receivers for radio, television, telecommunications, calculating machines, automatic control, etc. Other subjects covered include high frequency amplifiers, changes of frequency, filters, etc. (J. Quinet. Paris, Dunod, 1960. 2 vols., v. 1, 22 N. Fr.; v. 2, 29 N. Fr.)

POUR PROTEGER LES METAUX, 3. ed.

This small manual describes various methods of metal finishing. Some of the topics covered include: surface prepara-

(Continued on page 190)

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MEMBERSHIP

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Indexed in
The Engineering Index
The Applied Science
and Technology Index

Printed in Toronto

Price $6.00 a year in Canada, British Possessions, United States and Mexico, $7.50 a year in Foreign Countries. Current issues, 75 cents a copy, back issues from $1.00 per copy up. To members, affiliates and other bona fide engineers in Canada—no charge. Authorized as second class mail, Post Office Department, Ottawa.

Meet the Authors

Russell E. Potter, M.E.I.C., B.Sc. Civil (Saskatchewan), Consulting Engineer, Victoria, B.C. *(Moran Dam and The Fraser River).*

In 1948 Mr. Potter was appointed executive assistant to the Fraser River Basin Dominion-Provincial Board. He was commissioner on the B.C. Public Utilities Commission and later Project Engineer for the Moran Power Development Company Ltd. In 1957 he started his own consulting practice in Victoria.

Vladimer Bakanowski, M.E.I.C., Principal Computation Engineer, Engineering Department, Du Pont of Canada Limited, Montreal; **Robert N. Boyd,** M.E.I.C., B.A.Sc. Mechanical (Toronto), Supervising Engineer — Design Services, Du Pont of Canada Limited, Montreal. *(Electronic Computation in the Chemical Industry).*

Mr. Bakanowski received his engineering degree from the State College of Machine Construction and Electrical Engineering in Poznan, Poland. After serving as assistant to the general manager of the Lublin Aircraft Plant he came to Canada in 1942 and was engaged as chief designer for Bloctube Controls, Montreal, then joined the R.C.A.F. He left his position as machine designer with Montreal Locomotive Works to join Du Pont in 1950. He is a member of the Canadian Association for Computing and Data Processing.

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Mr. Gregory was a research engineer with Anglo-Canadian Pulp and Paper for four years, including one year on loan to Anglo Paper Products research group.

Mr. Mardon has published many technical papers, lectured extensively and been actively associated with a number of significant developments in the paper industry. In 1956 he was one of the recipients of the Weldon Gold Medal (C.P.P.A.), and in 1959 he won the City and Guilds Insignia Award. He is a fellow of the Royal Institute of Chemistry, (England), a member of the Institute of Fuel (England), an associate member of the Institution of Chemical Engineers (England), and a member of various other professional associations.

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Mr. O'Blenes, along with all the other authors of this paper was formerly with Anglo Paper Products, Ltd., of Quebec City.

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Dr. Ford joined the University of Alberta in 1942 and was appointed department head in 1959. During the past ten years he has maintained a consulting practice in applied mechanics and structures. He is a Member of Council of the Association of Professional Engineers of Alberta and a member of the American Society for Testing Materials.

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COVER ILLUSTRATION

A TR-10 Pace analog computer being used to obtain a dynamic solution to an engineering problem. Photo courtesy Electronic Associates Incorporated.

MORAN DAM AND THE FRASER RIVER

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Today the Fraser River is out of the power picture in British Columbia. Yet it lies closer to the load centre of the Province by several hundred miles than either the Peace River or the Columbia. It has more power potential than both the Canadian Columbia and the Peace River combined and could produce power at tidewater at less than one-half the average of those two rivers. It has the site for the world's greatest power plant.

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

THIS ONE power plant would turn out power at comparable cost to the lowest in the world; remove the flood menace of the Fraser River;[4] improve navigation to such an extent that the river could be used for an additional 30 miles and probably solve the silting problem of the river. Dredges now remove silt in the lower Fraser at a cost of over $1 million per year.

The reason that the river is not being considered is because of the salmon involved. A short picture of the salmon problem should be shown before going into the power systems possible on the river. The Fraser is a great salmon producing river. It produces all species of salmon like many other British Columbia rivers but its main claim to fame is that it is the largest sockeye producer. Tinned red sockeye brings the highest prices in the industry although it is no higher in food value than the other species, which are all about the same.[1]

To get a true picture of the salmon catch in British Columbia it is necessary to examine four consecutive years. The sockeyes are predominantly a 4 yr. cycle fish. The chum is also a 4 yr. fish, while the pinks have a 2 yr. cycle. The springs may not spawn for 5 or 6 years, or more, but they are a small part of the catch. All species invariably spawn only once. The fish are caught as they return from the sea to their home rivers to spawn. There are a number of important sockeye races and some return each year. The pinks, however, occur in the Fraser only in the odd years, 1951-53-55 cycle. In 1954 only 17½ cases were packed but in the next year the pack was 160,187½ cases. In other rivers the pink run may be in the even years so that the pink salmon catch of the province only varies about two to one on the even and odd years.[2] Even with such great variations occurring the salmon catch in British Columbia has a uniformity that is remarkable. The total salmon catch of a two cycle period of 8 yr. was as follows, all figures being in 48 lb. cases with part cases omitted.[2] (see Table 1.)

The salmon catch of British Columbia, as well as the Fraser River, is made up of five species of salmon and the steelhead. The steelhead is not a true salmon but is caught with them and included in the salmon figures. The pack of the Fraser in the last 4 yr. is as follows, in full cases.[2] (see Table 2.)

On the Fraser River, and probably the other large salmon rivers as well, only the sockeye is likely to be seriously affected by the power schemes. All of the other species of salmon are, for the most part, river spawning fish and the young fry head out to sea soon after hatching, or stay in the river itself for a few months or a year.[1] The sockeye, however, travels to the tributaries of the river on which there are large lakes. Some of these will be close to the sea like Pitt Lake and Harrison Lake, just off the delta and below the power sites; others will be 400 to 600 miles upstream like Stuart Lake and Chilko Lake. The sockeye spawn in the tributaries of these lakes. The young fish find their way to the lake and there spend a year or more before going down to the sea to return in their fourth year to the place where they were spawned. There they spawn and die leaving the life of their cycle in the eggs placed in the gravels of the river. This is, generally, the picture of the sockeye cycle.

The most notable run of sockeye salmon occurs in the South Thompson River. It is called the Adams River run and it occurs in the 1950-54-58 cycle. Here every 4 yr. more sockeye are produced than in all the other parts of the river in the entire 4 years. In the Moran Dam scheme this area was not affected. If the full power of the Fraser was to be developed this area would also be affected as there are plans for dams on the Thompson River as well as on the lower Fraser. While it may be possible for fish to pass one, or even two dams, it is believed that the added delay of several dams would eliminate all runs from a river.[3] The story of the Fraser River salmon is very well shown in the annual reports of the Provincial Department of Fisheries up to 1956 from which all of the above figures were taken. This report is now found in the Report of the Department of Recreation and Conservation.

Preliminary Report

The power story of the river has now been reported by the Fraser River Board in their "Preliminary Report on Flood Control and Hydroelectric Power in the Fraser River Basin"[4] presented to the Federal and Provincial Governments in June of 1958. This report outlines three systems which cover power and flood control on the river. The flood control requirement which is the same for all systems is a minimum of 9.23 million acre feet.

System 1.

Has a usable storage of 16,421,000 acre ft. and 5,089,000 kw. of "nominal prime capability". This last phrase is defined as the maximum load a machine can carry under the most adverse conditions.[4] It is more generally known as firm power and will be so called in the following.

System 2.

Has a usable storage of 26,989,000 acre ft. and 5,341,000 kw. firm. This system includes the Moran Dam, and is the only one of the three that does. The other 2 systems show the Moran head divided into 5 dams.

System 3.

Has a usable storage of 16,586,000 acre ft. and 5,159,000 kw. firm.

Cost

The cost of each of these Systems is placed at about $2 billion. This figure includes transmission and step-up transformer costs amounting to "more than $40. per kw. of installed capacity and more than $60 per kw. of assured energy production."[5]

For System 1. the power cost is given as $1,969,325,000 with an installed capacity of 7,198,000 kw. and firm power as above. This gives a cost of $274. per installed kw. or $387. per kw. firm, including the above transmission costs. In the usual figures of costs per installed horsepower this figure, without transmission, becomes $175. System 3. is much the same. System 2. with Moran Dam shows even better cost figures. The total cost is $1,988,310,000 with installed capacity of 8,001,000 kw. or 10,700,000 hp. Installed figures are therefore $249. per kw. and $185. per hp. less $40. and $30. respectively for the included transmission costs, the net generation costs being $209. per kw. and $155. per hp. installed.

The difference between the three Systems is more or less academic at this stage but they demonstrate that there are enough damsites and storage areas to control the flood of the Fraser in several ways and to develop the entire power of the river without necessarily using any one site to its maximum height, or perhaps leaving it out altogether. In Systems 1. and 3. Moran is developed to only 200 ft. rather than to 720 ft. as in System 2.

System 2. is the spectacular and intriguing plan for the river as it hinges on the mighty Moran Dam. This damsite has been known for many years but it was not until 1954 that a group of men asked the Provincial Government for the right to develop it. This is truly a remarkable power site. The dam proposed, a concrete gravity arch, would raise the river 740 ft. in the Company plan,[6] or 720 ft. in the Report plan.[4] In the conservative words of the Report on page 86 it says: "The generator installation proposed is 3,600 MW, truly an immense project which, if it were built, would dwarf all others on this continent." 3,600 mw. is equivalent to 4.8 million hp.

The Premier was naturally interested but said: "Satisfy the Fisheries people and then come back and see us." This condition had, of course, been expected and did not seem too difficult. The Company at this time believed it had an effective method of guiding the fish electrically.

The problem of taking the adult fish over the dam by mechanical means seems to be the most feasible. Fish ladders miles in length and on steep canyon walls are out of the question, but short ladders leading to large tanks mounted on cars, moving up and down the face of the dam, are quite practical. The number of fish to be handled may be as high as 750,000 in a 24 hr. period, according to an estimate by the Fisheries Department in another study of the river.[7] This is some ten times the maximum number of fish in the river today at this site but indicates what they hope to achieve. Objections have been raised that the fish would be lost in the lake above, but it should be remembered that these same fish will normally travel through larger lakes before they reach their spawning grounds and the 40,000 cusecs through Moran Lake will give much more current to guide them than in the lakes ahead. In any case all of the fish going up will have come down through this lake as fingerlings.

The problem of handling the fingerlings has always been a major one. These 1 yr. old fish which make their migration to the sea with the spring flood have always been considered the most difficult to save. Going through the turbines would kill them

Table I

Year	*Total B.C. Salmon Catch All species*	*Fraser River Salmon Catch All species Canadian Pack*	*Fraser River Sockeye only Canadian Pack*	*% Fraser River Sockeye is of B.C. Salmon All species*
1951	1,957,520	268,233	145,321	7.4
1952	1,305,160	151,147	134,625	10.3
1953	1,826,588	496,936	191,123	10.4
1954	1,747,854	563,807	*497,023	*28.6
1955	1,401,298	294,238	103,678	7.3
1956	1,112,844	113,954	88,132	8.0
1957	1,408,976	204,909	121,965	8.7
1958	1,900,174	622,844	*606,669	*32.0

*Adams River run 1950-54-58 cycle. The American catch in the 8 year period was a little less than the B.C. catch.

Fig. 1. Aerial view of Moran dam site

or even going over a dam could be fatal.

It has been established that on their migration the young fish keep mostly in the top 15 ft. of water.[8] Few are found below 30 ft. They follow the current and in an ordinary dam this means they would pass into the turbines or over the spillway. At Moran, with a dam over 700 ft. above the tailwater, the turbine inlets would be placed 100 ft. below the lowest drawdown. The regulating gates for passing the flood waters would also be at a similar or greater depth, the dam being designed so that no water passes over a spillway. No small fish would get to such depths and the spring flood that brings them down would put the gates under an even greater depth of water.

The problem then is to create a surface current to the face of the dam and allow enough water to pass through to attract the small fish. This can be done through gates placed in the face of the dam to the maximum drawdown level. The water may then be flumed or even sent over a fall into a deep tailrace pool, it having been determined that the small fish survive such a free fall safely.[9] Both the lift method for the adults, and the flume and fall method for the fingerlings are now being used at various places in the States of Washington and Oregon. I have not seen an actual statement of their losses, if any. The reference quoted is most optimistic.

One Dam

This scheme was worked out over a period of years after it was found that guiding fish by other means was not practical. It appeared that it might be possible to save the salmon if only one dam was built on the river. If this dam were big enough to give complete flood control and an immense amount of power perhaps no other development, at least downstream, would need to be built. The next move was to go to the Fisheries people and try to work with them on the design but this was a false hope. If the rivers are left untouched fishing should get no worse and may get much better. The hope of the Fisheries is to keep all dams off salmon rivers, which means most of the rivers of British Columbia. This will eliminate an estimated two-thirds of the hydro potential of some 22 million kw. firm, only 2.1 million of which has been developed so far. 22 million kw. firm represents an installed capacity of 46 million hp.[10] On the basis of most government reports we can assume that this is a conservative estimate.

So far there has been little or no basic information on the problem of handling salmon past dams. If we must go back to basic research such a program would take 20 to 50 years and probably would come up with the answer that there is no way to solve the problem. It therefore seems that we must face the fact that the choice has to be made for either power or fish on the Fraser River and that we cannot have both.

Ten Dam Scheme

In the Ten Dam Scheme[3] designed to develop the water of the Columbia diverted down the Fraser, the design for fishways amounted to $350 million, with the uncompromising statement that they would not save the fish.[11] In the design of the Moran Dam approximately $50 million was allowed for fish handling devices. A concrete arch was used as the annual runs of salmon could be taken past during construction. However if this were not required a rockfilled dam could be used at a cost reduction of an estimated $100 million. It is quite evident that unless a sure method of passing fish over dams is evolved the attempt should not be made.

The Fraser River Board has examined the power potential of the Fraser and placed it at over 5.34 million kw. of firm power, with an installation of 10.5 million hp. This system also has nearly three times the minimum flood control capacity. The energy is placed at 45 billion kwh. annually. At 6.5 mills, the cost of thermal power, this amount of energy is worth $292.5 million per yr., as a wholesale figure. The retail figure is placed at over $800 million.[12] The value of industry in annual production that would use this amount of power might be placed at many times this figure. At half this mill rate the returns would about meet the requirements of the development.

Moran Dam was estimated at $512 million in 1956 by J. L. Savage of Denver, Colorado, consulting engineer for the Company. This estimate included two transmission lines to the Vancouver area. Its energy output was placed at 20 billion kwh. annually. A 10% gross return would be paid by 2.6 mills at these figures.

An interesting chart was worked out to indicate the loss of salmon if Moran killed off all of the sockeye that go above this point on the river. If the sockeye of the Fraser River were all killed off it would mean that on the Adams River cycle every four years the British Columbia salmon catch would be down 25% to 32% but on the other three years it would be down only 7% to 15%. These are only in the nature of annual variations as can be seen from Table 1.

Sacrifice

It is quite evident that there is no hope of developing the entire power potential of the Fraser without losing sockeye, and the same must be assumed for even the one dam at Moran. For this reason we now feel that the only approach to the power question is to concede that the sockeye pack, or at least a large part of it, on any salmon river will be sacrificed. This premise at least clears the air and places each resource on its own merits.

The figures used have ignored the United States catch of Fraser River sockeye which is a full 50%. The recent alteration to the Treaty calls for the same division of the pink salmon. The alternative to Canada selling out one-half of the Fraser to the United States was to have no Fraser River fish at all. The bulk of the Fraser sockeye return to the river via the Straits of Juan de Fuca and the United States fishermen get at least an even chance at them with the Canadians. As early as 1900 it was realized that an International agreement was required. To conclude the agreement took 37 years. It is highly probable that any power development on the Fraser will be most unpopular across the border and we will find that our own Fraser River has international complications.

A strong plea is made that salmon is an irreplaceable food, but it is easily shown that the beef that could be raised in the Cariboo, if water were made available by raising the Fraser to 1540 ft. elevation, would far sur-pass the amount of salmon lost.[13] Unfortunately there is no alternative supply of water for this land, so we cannot have both the salmon and the beef. Again it is one resource or the other.

The question of where we will use all of this power has been answered by a study made for the Company[6] by the British Columbia Research Council and also by the Fraser River Board. On page 73 of the Report it says: ". . . it is safe to assume that a market will exist in the future for all the power that can be produced economically from the basin." The Fraser River Board evidently made a slight concession to the fish by not including any dams on the Thompson River. However this was theoretical as the four dams on the main stem below Lytton would eliminate the sockeye runs.[14] There would be no reason not to develop the Thompson between Lytton and Kamloops if the lower Fraser were developed. At least another 750,000 kw. firm or 1,000,000 hp. of installed capacity can be generated from the regulated water of the South and North Thompson Systems. The total power available in the Fraser System is therefore at least 11.5 million hp.

The biggest run of Fraser River sockeye in recent times was in 1958 when 606,669½ cases were packed. At $1.00 per lb. this is a value of about $29 million. However, that occurs only once in four years. The lowest year of that cycle was 1956 with 88,132 cases worth $4 million. The four year cycle average was 230,111 cases, worth $11 million. The electric power from the regulated Thompson River alone would have a value at $25 per kw. yr., equivalent to 2.85 mills per kwh., of $18,750,000.

Table II

Year	*Sockeye*	*Spring*	*Steelhead*	*Coho*	*Pink*	*Chum*	*Total*
*1958	606,669	2,709	181	3,203	612	9,468	622,842
1957	121,965	3,126	429	4,836	68,968	5,585	204,909
1956	88,132	2,873	337	12,273	348	9,989	113,954
1955	103,678	6,843	269	15,910	160,187	7,350	294,238

*Adams River cycle.

Just what a large block of low priced power would do for Canada and British Columbia is an interesting study:

a. In the years 1954 to 1958 inclusive we shipped out of Vancouver 3.67 tons of material for every ton we brought in;[15]

b. The world market for light metals, chemicals and manufactured goods requiring power as a substantial part of their cost is growing rapidly;

c. The manufacturing centre for these products will go anywhere in the world where there is low cost power in large quantities;

d. Tremendous quantities of bauxite have recently been found in Australia in the Wiepa District, and in the words of the Australian High Commissioner they ". . . look forward to selling their alumina to the west coast of North America."[16] Our ships could travel both ways loaded with lumber or alumina.

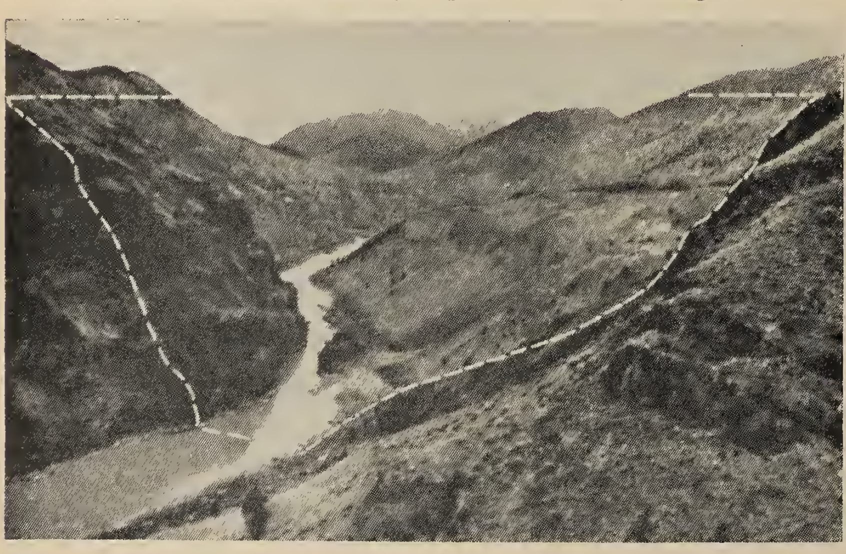
British Columbia could become the primary industrial centre of the Commonwealth and one of the great ones of the world.

At the Eleventh Natural Resources Conference of British Columbia in 1958 the question was asked of the power panel: "At what price per kilowatt hour at tidewater must electricity be available to attract the following industries: aluminum, magnesium, titanium . . .?" The answer was given by Mr. C. C. Marshall of Sir Alexander Gibb and Partners, an engineering company with worldwide experience. ". . . a price of four mills would be attractive, a price of three and one-half mills would be very attracttive . . .". Only the development of the Fraser River will supply immense blocks of power at such low prices at tidewater.

British Columbia needs primary industrial development to take care of the rapidly growing population. Primary industry fosters secondary industry and only power of all our natural resources can be developed and enlarged at will and as it is required.

It is quite possible that the people of British Columbia may prefer to keep their rivers for the sockeye but if they do they should understand exactly what their choice means to themselves and their children.

Fig. 2. Outline of Moran Dam superimposed on the site, looking North



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ELECTRONIC COMPUTATION IN THE CHEMICAL INDUSTRY

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It is no exaggeration to say that electronic digital and analog computers are revolutionizing the practice of engineering. In the past, much of our engineering was based on "judgment" which some cynics would describe as a euphemism for guesswork based on a highly empirical approach. Our available problem solving methods in many cases were so limited that simplifying assumptions were needed, often in such numbers that the mathematical model obtained bore little resemblance to the physical situation. Hence the need of "judgment" in quotation marks. Electronic computers are changing all this. These new tools do of course, reduce the time and effort needed to perform difficult calculations. Of vastly greater importance, however, they produce better and more economic solutions through the use of more analytical methods, requiring fewer of the simplifying assumptions formerly used. Because of the speed with which solutions can be secured, it is possible when designing equipment, for instance, to prepare several designs and to pick the optimum, rather than to use the first design made, as was often the case in the past.

THE ABILITY to simulate complex chemical and mechanical processes is a treasure-trove, the value of which is even today, not completely known. While the use of "judgment" has been decried, the development of the proper input data for a computer, and the interpretation and analysis of the results obtained will always require sound engineering judgment which can never be replaced by a machine.

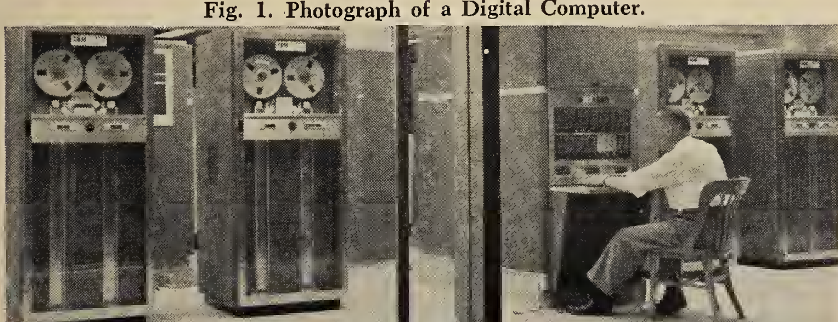
Although the use of electronic computers in the chemical industry is a comparatively recent development, their use in other fields, notably the aircraft industry, has been well established for some twenty years. Indeed, Government specifications for aircraft components frequently require that designs, before acceptance, be proven by computer calculations. Tribute must be paid to the pioneers who developed the equipment and the basic techniques which are now being applied in the chemical industry.

This paper deals with the application of two basically different types of electronic computers, namely, digital and analog. Each has characteristics that recommend it over the other for certain types of computation. There are very few classes of problem which can be handled on either machine with equal facility. In order to explain the areas of application, the paper describes the characteristics of each type of computer, and then presents brief references to typical problems solved by each. Their use is further illustrated by a description in some detail of two specific applications. The paper concludes with some remarks on policy and cost considerations that are of interest to management.

Characteristics of Digital Computers

A typical medium size digital computer is shown in Fig. 1. This is an I.B.M. Type 650, with floating decimal point attachment. One of these has been in use in the authors' company for the last three years. In the photograph can be seen the operating console and the four tape memory units. Not shown in the photo is the high speed unit for printing output data.

Fig. 1. Photograph of a Digital Computer.



Digital computers are basically high speed counting devices and are in themselves only capable of performing 6th grade arithmetic. The highly complex calculations that can be performed on these machines depend on the skill and ingenuity of the programmers who prepare the instructions in language that can be understood by the computers. These machines can easily handle large masses of data and are therefore widely used for accounting data processing. It has often been found that they can be justified for accounting work alone, and any profitable technical applications that are developed amount to a welcome dividend.

The accuracy of a digital computer depends largely on the number of significant figures carried in the machine. The maximum size of problem that can be handled is in large measure independent of the size of the installation. Since solutions are obtained by sequential operations, doubling the problem size on a given machine will double the solution time.

The data supplied to, and the results obtained from, a digital computer must be in the form of discrete numbers. The machine is controlled by a "program" specially developed for the particular problem. If the problem is of a repetitive nature, such as the design of metering orifices, the program can be kept in a library and can be re-used whenever a similar problem is encountered.

Because of the fantastically high operating speeds of modern digital computers, they are particularly effective for the iterative calculations used in trial and error solutions.

Characteristics of Analog Computers

A typical analog computer is shown in Fig. 2. This is an Electronic Associates Pace computer. Visible at the operating console is the "pre-patch" panel, which can be wired away from the machine for the particular problem, and can be inserted into the machine when the problem is ready to be run. The knobs below the panel control calibrated precision potentiometers which are used for setting the coefficients of the problem.

The problem solution can be read on the digital voltmeter to the left of the pre-patch panel, but the results are more often read in continuous form on auxiliary equipment not shown in the photograph. These devices may include a multi-channel strip recorder, X-Y plotter, or cathode ray oscilloscope.

Analog computers use electrical components as the analogs of the physical or mathematical entities being represented. The machines are highly sophisticated—they can, for instance, solve nonlinear higher order differential equations with ease.

These devices are usually limited to problems satisfied by answers having three or four significant figures, and accuracy is entirely dependent on the quality of the components and of the installation.. The maximum size of problem that can be solved is dependent on the size of the installation since the operations are performed simultaneously rather than sequentially as in the case of digital computers. For the same reason, solution time is largely independent of problem size and most solutions are obtained in one minute of machine operation or less.

Input data may be in discrete numerical form but can also be in continuous graphical form. Likewise, results may be discrete or continuous. Very frequently the most useful results are obtained from the multi-channel strip chart recorder.

Before a problem can be run, the pre-patch panel must be wired, an operation that may require a few hours. By this means, the various problem solving components available in the machine are selected and connected together to obtain a representation of the physical problem. These components include summers, integrators, multipliers, function generators, coefficient setting potentiometers, etc.

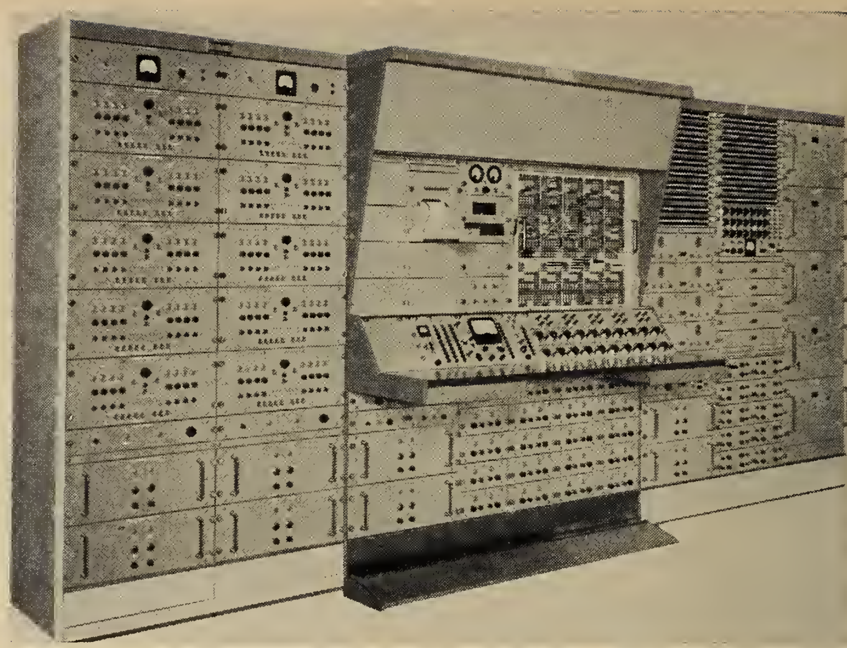


Fig. 2. Photograph of an Analog Computer.

Analog computers are particularly well adapted to the simulation of the performance of chemical or mechanical processes or equipment. When so used, they provide what is essentially a visual working model of the prototype simulated. The designer can, for example, readily examine the effect of varying catalyst concentration on the conversion rate and yield of a given chemical reaction. It is possible to change the time scale of the process to permit, say, the exploration of the mechanism of an explosion at rates slow enough to permit accurate recording. Another very important area of application is the study of the dynamic performance of automatic control equipment. It is possible to evaluate quickly the effectiveness of alternative instrumentation proposals, and to develop for the scheme selected the approximate adjustments required when the control devices are set up in the field.

Uses of Digital Computation

Literally dozens of successful applications have been made in the chemical industry. Probably the most outstanding from the standpoints of labour saving and better answers are the thermal design of heat exchangers, the static design of distillation columns, and the analysis of stresses in complex systems of piping. In the preparation of complicated process flow sheets having many recycle streams, much effort can be saved in determining the heat and material balances by the use of a program to solve the multi variable simultaneous equations that are required.

The calculation of ground level concentrations of atmospheric contaminants at various distances from stacks of various heights requires several days' laborious calculations using manual methods. With the development of a library program for this calculation, answers of high accuracy can now be obtained within a few hours.

Uses of Analog Computation

As mentioned earlier, analog computers are of great value in simulating the dynamic performance of individual pieces of process equipment, and of complete processes. The methods used will depend on the accuracy and completeness of the data available on the prototype. If full data can be secured, including complete reaction kinetics, equilibrium coefficients, etc., and if a sufficiently large computer is used, a detailed analysis can be performed. This will give results having an accuracy of up to four significant figures. Frequently, however, this type of analysis cannot be carried out because of incomplete understanding, because only trends are known, or because a sufficiently large computer cannot be used. Even under these limitations, valuable information on trends can be obtained from a simulation, although the accuracy may be considerably lower.

When a simulation of a distillation unit is performed, for example, alternative automatic control systems can be evaluated and the approximate optimum settings for the gain, reset, and rate functions of each of the automatic control instruments can be established. Such a simulation will also enable the operators to familiarize themselves with the column performance under various upsets in feed composition and flow, pressure, boil-up, reflux, etc. This information will greatly reduce the time needed to "line out" the distillation unit at initial startup and will, through better control, lead to greater throughput and more uniform separation.

Heat Exchanger Stress Analysis Using a Digital Computer

Tubular heat exchangers are widely used in the chemical industry. Many forms are used, a popular style being illustrated in Fig. 3. In this design, the process fluid may pass through the tubes, and if the unit is a heater, the tubes will be surrounded by a heating medium such as steam. Since the tubes are usually rigidly attached to the tube sheets, it is apparent that there will be differential expansion in the longitudinal direction due to the difference between the shell temperature and the tube temperature. This will lead to axial loading of the shell and tubes. The unit illustrated is also subject to other loading resulting from internal pressure in the shell, flexure of tube sheets due to differential hydrostatic pressure loading and to tube forces, and flange moments resulting from the other loads mentioned.

In order to diminish the total stress in the shell, tubes, tube sheets and flanges, tubular heat exchangers are frequently provided with "floating heads" or shell expansion joints. A typical shell expansion joint is illustrated in Fig. 3. Provision for thermal expansion such as this will increase the cost of the unit by 5 to 20% depending on the type of expansion provision made, as compared to the simplest form of heat exchanger, the fixed tube sheet type.

To decide whether the cheaper fixed tube sheet unit can be used in any particular application, it is necessary to carry out a very laborious stress analysis of the entire unit. This calculation usually requires about five

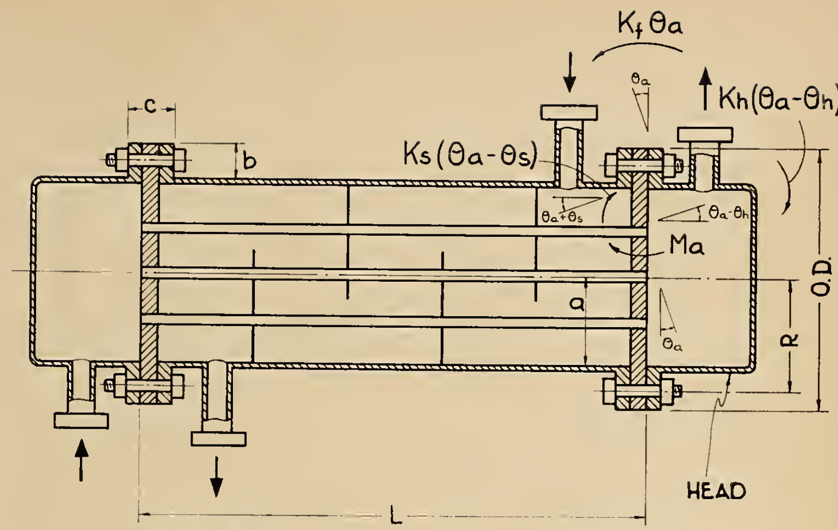


Fig. 4. Cross Section of Fixed Tube Sheet Heat Exchanger.

days if done using manual methods with the aid of a desk calculator. Frequently, provision for expansion is specified arbitrarily, without analytical proof because sufficient know-how and time are not available to carry out the necessary stress analysis.

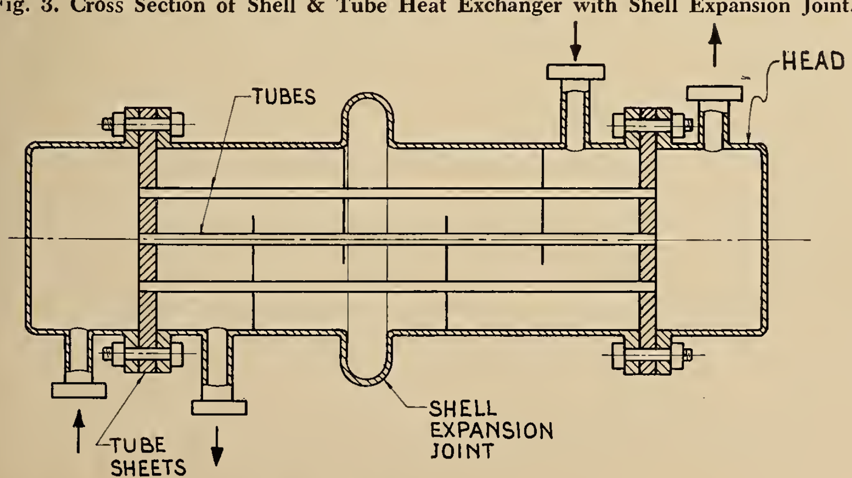
In the authors' company it was felt that the potential savings from the elimination of unnecessary expansion provision in new heat exchangers were great enough to warrant the development of a digital library program to perform the laborious calculations that are required. Such a program has been successfully developed, and is now in use on a routine basis. Running time for the program using an I.B.M. Type 650 computer, is approximately four minutes contrasted with the previously mentioned figure of five days for manual computation.

The mathematical basis for this program is presented in Appendix 1. It was written in Bell interpretive language and contains approximately 800 orders. The program is so arranged that the worst combination of process conditions to which each component is subjected is determined, and is used to calculate the loading and stress in that component. Allowance is made for the stiffening effect on the tubes of baffles, if used. One minor limitation is that the program is restricted to units having the tubes arranged in triangular pitch.

The input data for the program, which are provided by the design engineer, consist of twenty-nine items. These are provided to the computer operator by means of the form shown in Fig. 8. This information is punched on the input cards and these, together with the program deck and the Bell interpretive deck are fed into the computer.

The output data having the form shown in Fig. 11 are printed by the computer's high speed printer. The program is arranged to print each of the desired results in a specific line and column of the printout. The significance of the various numbers is indicated by the notes in the table. All results are printed in Bell floating decimal point notation in which the location of the decimal point is given by the last two numbers. For example, the maximum tensile stress in any tube, under given operating conditions, might be 2274375552, and should be read as 227.4 p.s.i.

Fig. 3. Cross Section of Shell & Tube Heat Exchanger with Shell Expansion Joint.



Because of the ease with which results can be obtained with this program, the design engineer frequently specifies several "cases" for computation. In this way he is able to assess the need of provision for expansion for several alternative designs. He can thus select the least expensive satisfactory design and be confident that thermal overstressing will be prevented.

This program has now been thoroughly tested, and is being used on a routine basis in the authors' company by all engineers who are responsible for the design or selection of tubular heat exchangers.

Simulation of a Continuous Chemical Process Using an Analog Computer

Nitric acid is manufactured in the authors' company and elsewhere by the oxidation of ammonia in the vapour phase under pressure. A simplified flow diagram of the process is shown in Fig. 5. Ammonia is stored in liquid form in two horizontal storage tanks equipped with steam heating coils. Liquid ammonia is forced out of the bottom of the tanks, to the vaporizer, under the influence of its own vapour pressure which is maintained by the heating coils. Flow of liquid ammonia to the vaporizer is regulated by a flow control valve, with cascade control by means of pressure within the vaporizer, where the liquid is vaporized by steam heating coils.

Ammonia vapour then passes through a pressure reducing valve and a temperature controlled regulating valve to the mixer. In the mixer the vapour is mixed with compressed air which is preheated in the shell side of a heat exchanger. The exothermic reaction takes place in the reactor in the presence of a catalyst and the reaction products consisting of oxides of nitrogen, water vapour and nitrogen are then cooled by passing them through the tube side of the heat exchanger previously mentioned. The mixture is then further cooled in the cooler condenser. Condensate is removed in the acid separator and the oxides of nitrogen are passed to the absorber where they are further oxidized and absorbed in water. Nitric acid in finished form is pumped from the bottom of the absorption column to storage.

It was decided to simulate the operation of this unit in order to secure more complete information on the performance of the reactor and the ammonia system under automatic control during various process transient conditions. It was hoped to develop new knowledge of the performance of the plant in order to optimize yield and throughput, to guarantee safe operation, and to establish the best methods of switching from one ammonia storage tank to another. The latter is significant since the ammonia storage tanks were located about 800 ft. from the ammonia vaporizer. This resulted in a pressure oscillation in this long line similar to water hammer under certain operating conditions. The pressure fluctuations were reflected in changes in pressure all the way to the reactor, and resulted in process yield lower than that obtainable under uniform conditions.

It might be asked "why not carry out the necessary investigation on the unit itself, rather than simulate it on an analog computer?" One reason was that it was desired to study several different methods of automatic control, and various other ways of eliminating pressure fluctuations in the reactor. Such experimental work, if carried out on an operating plant, would result in much loss of production and would be very expensive. Furthermore the trial and error process would be very time consuming and could be hazardous.

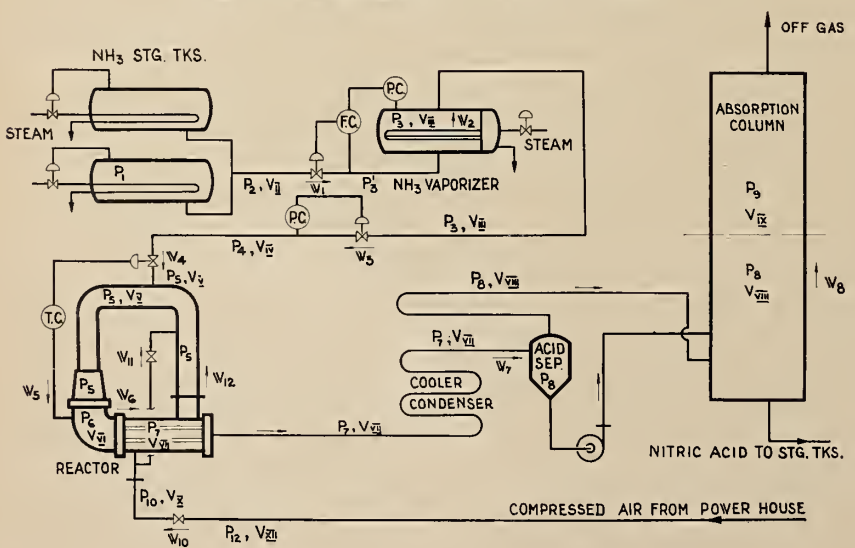
Since the study was concerned with process and instrument dynamics, an analog computer was selected as the most suitable tool for the analysis. The first step was to develop a mathematical model of the complete process, as described in Appendix II. Once this was completed the next step was to prepare a computer wiring diagram to establish the computer elements needed to represent the electrical analogs of the entities described by the mathematical equations. Part of the wiring diagram is shown in Fig. 6 which also shows the scale factors needed to represent the problem within the limitations of the voltage ranges available in the computer. The various symbols of the wiring diagram denote the various machine components used for the problem. Meanings of the symbols are described in the Handbook of Automation, Computation and Control.[1]

The pre-patch panel on the Pace computer was then wired in accordance with the wiring diagram, the coefficients were set on the proper potentiometers, and the arbitrary functions were set on the necessary function generators. This particular problem required a total of 108 operational amplifiers. To operate the simulated plant, external disturbances were introduced at selected points and the response to these disturbances was observed by noting the changes in selected variables on an eight channel strip chart recorder. To assess the effect of a change, say in control valve size, it was merely necessary to change the setting of the potentiometer which represented the control valve capacity, repeat the external disturbance, and observe its effect.

In Fig. 7, for example, the effect on liquid ammonia flow to the vaporizer of an external disturbance of 10 p.s.i./sec. is shown. A disturbance of this magnitude could occur, for instance, when switching from one ammonia feed tank to another. The record shows that if ΔPv, the pressure drop across the liquid ammonia flow control valve is less than 10 p.s.i., the resultant pressure surges in the long ammonia feed line are not damped; with ΔPv over 10 p.s.i., however, the surges are very quickly damped out. Fig. 9 shows the effect on actual reactor temperature of these disturbances. A disturbance introduced at time "*A*" resulted in a swing of about 20 units of temperature about 6 sec. later. Following adjustment of some of the instruments, the same disturbance introduced at times "*B*" and "*C*" led to somewhat smaller temperature swings. Provision of some surge capacity in the ammonia piping system resulted in the charts shown in Fig. 10. The 10 p.s.i./sec. disturbance at time "*D*" resulted in a reactor temperature swing of about 14 units. Further "tuning" of the control instruments resulted in lower swings, that following the disturbance at time "*G*" being about 10 temperature units. Figs. 7, 9, and 10 were traced from the actual strip chart records.

This simulation was highly successful. It revealed information about the dynamics of the process and process equipment which had never previ-

Fig. 5. Flow Diagram of Nitric Acid Plant.



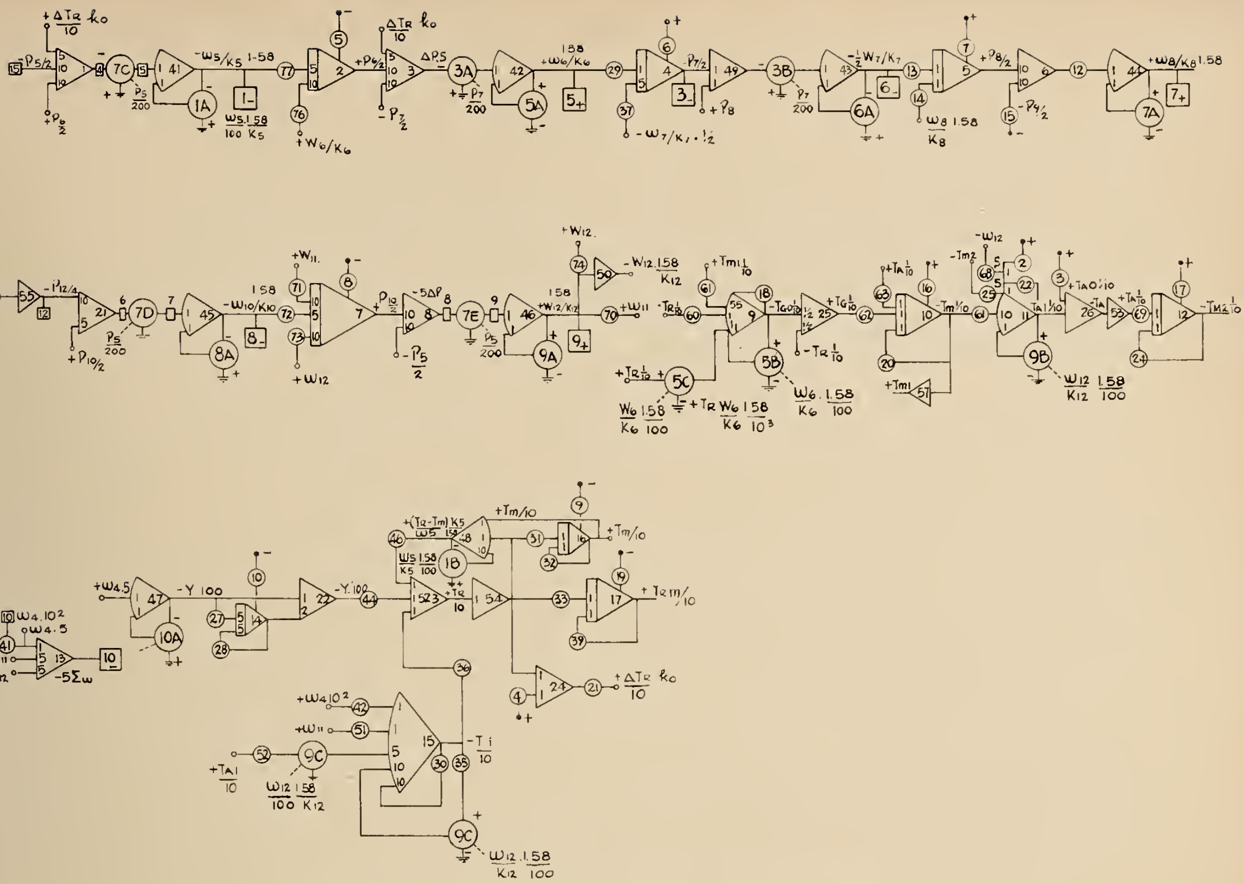


Fig. 6. Part of the Analog Computer Wiring Diagram.

ously been known or appreciated. It enabled the causes of reactor pressure fluctuations to be thoroughly investigated and led to the development of various remedial measures including automatic controls and changes in line capacity. The effectiveness of various safety features was evaluated and the most promising features were thoroughly tested.

Since the system improvements selected as a result of the simulation have now been incorporated into the prototype process unit, there has been ample opportunity to assess the value of the analog simulation. The comparison has shown that the simulation was without question an effective and failthful replica of the plant itself. All components including the automatic control devices, have performed in the manner predicted by the analog computer.

Policy Considerations

In embarking on a technical computation program, management should realize that results will not come quickly. A lengthy period will be required to develop the proper attitude on the part of the organization, to train the staff, to select adequate equipment, and to produce the first paying results.

In attempting to make money from technical computation, experience has shown that one of the biggest obstacles is the recognition of paying problems. Of lesser difficulty is the formulation of the problem, that is, the development of a mathematical model of the physical situation. The translation of the formulation into language that ean be understood by the computer, and the actual running of the problem on the machine, are comparatively easy.

At one time, it was thought that it was sufficient to obtain a computer, to give training in computer operation to the engineers, and to assist the engineers in running a few problems to demonstrate the computer's potential. It was expected that management could then stand aside and let the computer and the engineers grind out the profitable solutions that were sure to follow. This approach, unfortunately, did not work. It led to disappointingly few paying applications. It is now recognized that something more basic is needed in order to stimulate the fundamental analytical approach needed to recognize and solve paying problems. The best way to do this has probably not yet been discovered. Certainly the approach will vary with the type of organization and with its objectives.

In the authors' company, management believe in the future of engineering computation and encourage members of the engineering staff to familiarize themselves with the techniques and equipment. The open-shop approach is used; programming training is being made available to all who desire it and all are encouraged, after training, to make use of computers in the solution of technical problems. Another aspect of our approach is that the responsibility for results has not been delegated to mathematicians who would, perforce, have to learn enough about engineering to enable them to understand the problems presented to them. The responsibility has rather been placed on the shoulders of the engineers whose university training in mathematics is sufficient for the solution of most of the problems encountered. Mathematical consultants have been made available, however, and their services are used for very difficult problems.

In order to stimulate the analytical approach needed to achieve maximum results in this field and to equip the staff with the additional knowledge required, the engineering department of the authors' company is sponsoring a course in advanced mathematics for all of its interested technical staff in the Montreal area. The course provides a review of analytical geometry and calculus, and covers other topics such as ordinary and partial differential equations, matrix

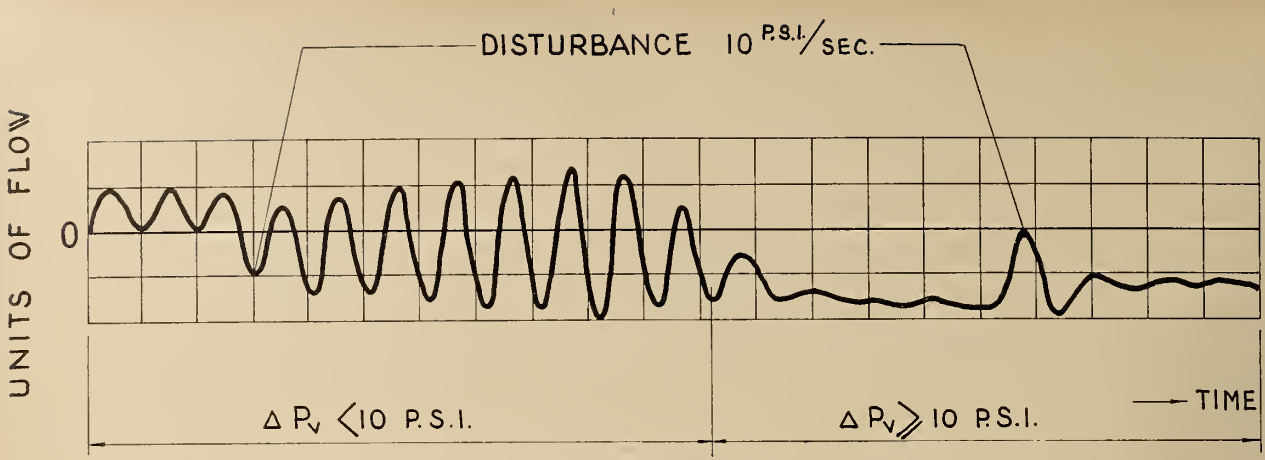


Fig. 7. Record of Effect of External Disturbance on Liquid Ammonia Flow To Vaporizer.

algebra, and theory of probability. The course is by design of a rigorous theoretical nature with as much emphasis on the derivation of theorems as on the solution of problems. It is being given by Dr. Hyman Kaufman, Associate Professor of Mathematics, McGill University.

In some organizations, technical use of computers has lagged because of a policy of allocating machine running cost (perhaps $200. per hr.) to the projects for which the computations were performed. A better policy would be to treat the computer as a necessary tool, and to charge its cost to overhead, in order to remove from the design engineer the burden of having to justify the machine each time it is used.

Cost of Engineering Computation

It is difficult to be specific about the cost of solving various types of problem by computer because every problem is different. The formulation and programming effort required for a problem will depend on its complexity, and will vary from a few man hours to several man months. The cost of a medium size digital or analog computer installation will vary from $100,000 to $500,000 and the rental charge for such facilities will vary from $20 to $200 per hr., depending on a number of factors. The machine running time will vary from a few minutes to several hours or even days depending on the nature of the problem. It is therefore apparent that the cost of solving a problem may vary from a few dollars to several thousand dollars.

At one end of the scale would be the calculation of metering orifices at a cost of about $15 per orifice. Once the data are developed, the cost of designing a fifteen plate distillation column to separate six non ideal components would be about $300 for the first case, and $100 for each succeeding case. Both of these calculations would be done on a digital computer using a library program. At the high end of the scale might be the simulation of a complex chemical reactor on an analog computer. The simulation might include the exploration of yield and controllability at various reaction temperatures and pressures, conversion rates, catalyst concentration, feed impurities, mass flows, etc. Such a study might cost $3,000 to $5,000.

Conclusion

The technical use of digital and analog computers is leading to important advances in the chemical industry. Design engineers are able to develop more efficient and more economic designs of new equipment and processes. Production and technical personnel are able through simulation of new and existing plants to secure with safety a new insight into their processes, thus leading to smoother startups, better operation, and increased yields.

FIG. 8.
REPRODUCTION OF TUBULAR HEAT EXCHANGER STRESS ANALYSIS INPUT DATA SHEET

Equipment No. 511N10

a	inside diameter, in.	27
E_s	modulus of shell material	29×10^6
E_{ts}	modulus of tube sheet material	27×10^6
E_t	modulus of tube material	27×10^6
E_c	modulus of channel material	29×10^6
L	overall length, outside tube sheets, in.	96
N	number of tubes	146
d	diameter of tubes, in. (ignore fins)	1¼
P_t	tube side pressure, lb/sq. in. ga.	150
P_s	shell side pressure, lb./sq. in. ga.	75
p	pitch, in. (triangular)	1½
t	thickness of tube wall, in.	0.011
T_t	maximum temperature of tube, °F.	270
T_s	maximum temperature of shell, °F.	150
T_t–T_s to be given		
ν_t	Poisson's ratio for tube	0.3
ν_{ts}	Poisson's ratio for tube sheet	0.3
ν_s	Poisson's ratio for shell	0.3
α_{ts}	coefficient of thermal expansion for tube sheet in./°F.	6×10^{-6}
α_t	coefficient of thermal expansion for tube, in./°F.	6×10^{-6}
α_c	coefficient of thermal expansion for channel, in./°F.	6×10^{-6}
α_s	coefficient of thermal expansion for shell	6×10^{-6}
t_c	thickness of channel, in.	⅜
t_s	thickness of shell, in.	⅜
h	tube sheet thickness, in.	1¼
l	maximum unsupported span of a tube which is considered as column built-in at tube-sheet and "pinned" at the support plate, in.	23
b	outer diameter of outside flange—outer diameter of shell, in.	4½
c	total thickness of two outside flanges, and tube sheet, in.	3¾

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Appendix I

Mathematical Basis for Heat Exchanger Stress Analysis

The basic differential equation and its solutions are as follows:[2,3,4,5,6]

$$x^4\frac{d^4q}{dx^4} + 2x^3\frac{d^3q}{dx^3} - x^2\frac{d^2q}{dx^2} + \frac{dq}{dx} + x^4q = 0 \qquad (1)$$

$$q = A \operatorname{ber} x + B \operatorname{bei} x$$

$$w = \frac{1}{\beta^4 D}\left[{}_fA(\operatorname{ber} x_a - \operatorname{ber} x) + B(\operatorname{bei} x_a - \operatorname{bei} x)\right] \qquad (2)$$

$$M_r = \frac{1}{\beta^2}\left[A\left(\operatorname{bei} x + \frac{1-\nu}{x}\operatorname{ber}' x\right) - B\left(\operatorname{ber} x - \frac{1-\nu}{x}\operatorname{bei}' x\right)\right] \qquad (3)$$

$$\Theta = -\frac{1}{\beta^2 D}(A \operatorname{ber}' x + B \operatorname{bei}' x) \qquad (4)$$

$$x = \beta \times r = \left(\frac{2k}{D}\right)^{1/4} \times r \; ; \quad x_a = \beta \times a \qquad (5)$$

$$k = \frac{N \times t(d-t)E_t}{a^2 \times L} \qquad (6)$$

non uniform effective pressure on the tube sheet is

$$q = (f_t \times p_t - f_s \times p_s) + k(m - \alpha_t \times T_t \times L - 2w) \qquad (7)$$

where p_t = hydrostatic pressure on tube side, p.s.i.

p_s = hydrostatic pressure on shell side, p.s.i.

f = fraction of total tube sheet area on which pressure acts directly.

m = distance the tube sheet edges move in respect to each other under load, in.

$$f_t = 1 - \frac{N}{4}\left(\frac{d-2t}{a}\right)^2$$

$$f_s = 1 - \frac{N}{4}\left(\frac{d}{a}\right)^2$$

When the shell side and tube side of the heat exchanger are subjected to pressure p_s and p_t—the edge rotation of a hinged semi-infinite cylindrical shell and head will accordingly rotate by an angle Θ_s and Θ_h, respectively.

$$\Theta_s = \frac{3^{1/4}(1-\nu_s^2)^{1/4}p_s}{E_s}\left(\frac{a}{t_s}\right)^{3/2} \qquad (8)$$

$$\Theta_h = \frac{3^{1/4}(1-\nu_h^2)^{1/4}p_t}{E_h}\left(\frac{a}{t_h}\right)^{3/2} \qquad (9)$$

The moment applied at the edge of a semi-infinite cylindrical shell, which will rotate the edge through a unit angle, defines the "rotation stiffness" of that edge. The following are the terms defining the "rotation stiffness" for the shell, head and flange of the heat exchanger.

$$K_s = \frac{E_s \times t_s^{5/2}}{2 \times 3^{3/4}(1-\nu_s^2)^{3/4} \times a^{1/2}} \qquad (10)$$

$$K_h = \frac{E_h \times t_h^{5/2}}{2 \times 3^{3/4}(1-\nu_h)^{3/4} \times a^{1/2}} \qquad (11)$$

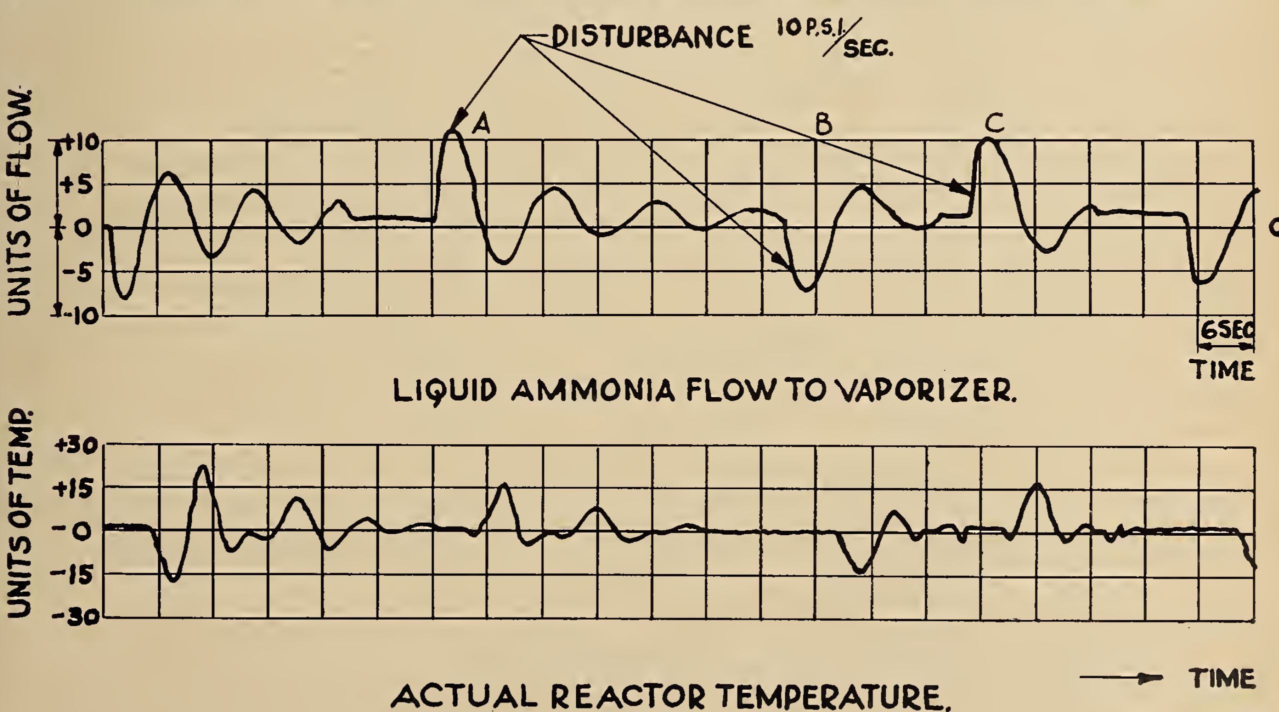
$$K_f = \frac{E_f \times I_f}{R \times a} \qquad I = \frac{b \cdot c^3}{12} \qquad (12)$$

where R = flange bolt circle radius, in.

b = (O.D. − I.D.)/2 of flange, in.

c = combined flange and tube sheet thickness, in.

Fig. 9. Two-Channel Record of Effect of External Disturbance on Reactor Temperature — before Adjustments.



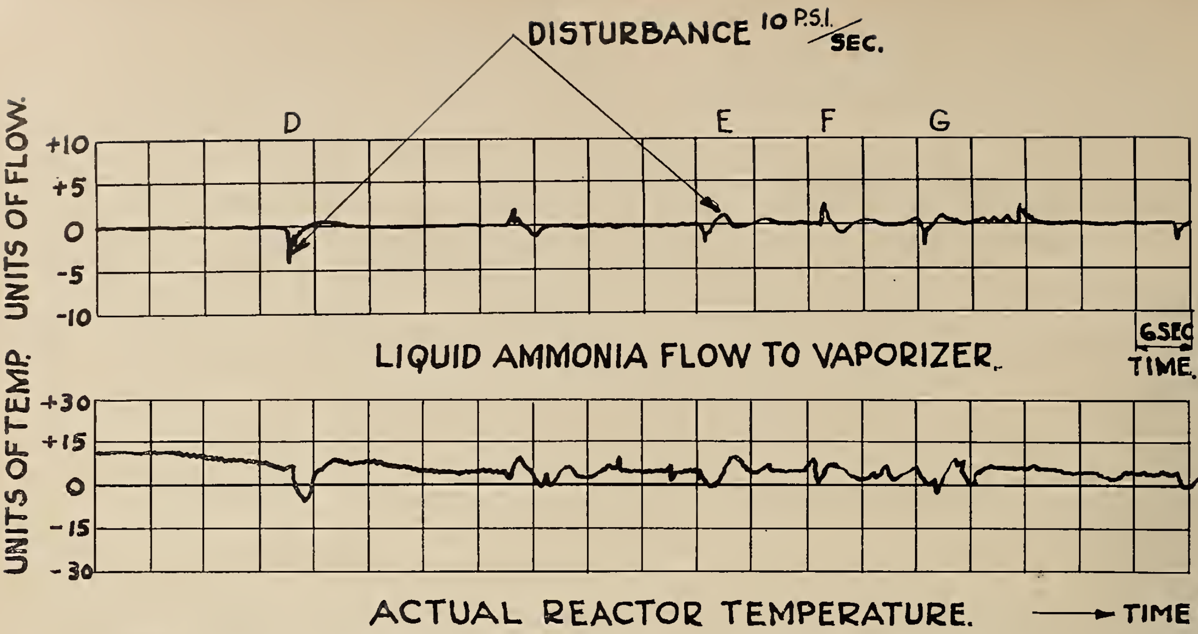


Fig. 10. Two-Channel Record of Effect of External Disturbance on Reactor Temperature—after Instruments were "Tuned Up."

Four edge moments must balance each other at the joint. This condition is reflected by the following equations:

$$M_a + K_s(\Theta_a + \Theta_s) + K_h(\Theta_a - \Theta_h) + K_f\Theta_a = 0 \qquad (13)$$

$$M_a + (K_s + K_h + K_f)\Theta_a = K_h\Theta_h - K_s\Theta_s \qquad (14)$$

Three conditions are needed for determination of the three constants m, A and B (equations 2 and 6); the equations describing these conditions are as follows:

In order to obtain the first equation the edge values of Θ_a and M_a are first obtained from equations 3 and 4 and substituted into equation 14, which yields:

$$A\left[\operatorname{bei} x_a + \left(\frac{1-\nu}{x_a} - \frac{K_s + K_h + K_f}{\beta D}\right)\operatorname{ber}' x_a\right]$$

$$- B\left[\operatorname{ber} x_a - \left(\frac{1-\nu}{x_a} - \frac{K_s + K_h + K_f}{\beta D}\right)\operatorname{bei}' x_a\right]$$

$$= \beta^2(K_h\Theta_h - K_s\Theta_s) \qquad (15)$$

The second equation is:

$$q_a = A \operatorname{ber} x_a + B \operatorname{bei} x_a$$
$$= km + f_t p_t - f_s p_s - k \times \alpha_t \times T_t \times L \qquad (16)$$

The third equation is:

$$\int_0^a 2\pi r q\, dr = \frac{2\pi a^2}{x_a}(A \operatorname{bei}' x_a - B \operatorname{ber}' x_a)$$

$$= \pi a p_t - \frac{2\pi a E_s t_s}{L}(m - \alpha_s \times T_s \times L) \qquad (17)$$

Once the radial moment value is obtained (see equation 3) the maximum bending stress is determined from the following equation:

$$\sigma_{\max} = \frac{6M_a}{h^2\eta_w} \qquad (18)$$

where σ = stress, p.s.i.
η_w = flexural efficiency for triangular pitch.

The load on any tube is given by the following equation:

$$W_t = \frac{\pi a^2}{N}(q - f_t p_t + f_s p_s) \qquad (19)$$

Approximations

$\sin^{-1}x$ is computed in accordance with Hasting's formula:

$$\sin^{-1}x = \frac{\pi}{2} - \sqrt{1-x} \times \psi(x) \qquad (20)$$

$$\psi(x) = a_0 + a_1x + a_2x^2 + a_3x^3 \qquad (21)$$

$a_0 = 1.5707288$ $\quad a_2 = 0.072610$

$a_1 = -0.2121144$ $\quad a_3 = -0.0187293$

Fig. 11. Reproduction of Computer Output Sheet.

TUBE SHEETS max. tensile stress		TUBE SHEETS max. compressive stress		TUBES max. tensile stress		TUBES max. compressive stress		SHELL absolute value of stress
0000000000	—	0000000000	—	000000 0	—	[1] 3321564752	—	0000000000
0000000000	—	0000000000	—	000000 0	—	[2] 4830773253	—	0000000000
0000000000	—	0000000000	—	000000 0	—	[3] 8226538452	—	0000000000
2113988654*		1632370654	—	2274375552	—	1694494354	—	2026288853

* This line shows stress values in the components listed.

E.g. highest tensile stress in tubes is 227.4 p.s.i. and highest compressive stress in tubes is 16944 p.s.i.

[1] Maximum allowable force when tubes are not supported by baffles (332 lbs.).
[2] Maximum allowable force when tubes are supported by baffles (4830 lbs.).
[3] Actual force at tube ends (822 lbs.).

Depending on values of x the approximations are as follows:[2]

For $0 \leq x \leq 10$

$$\text{ber}\, x = 1 - \frac{x^4}{2^2 4^2} + \frac{x^8}{2^2 4^2 6^2 8^2} + \frac{(-1)^{4k-1} \times x^{4k}}{2^2 4^2 \ldots (4k)^2} + \ldots \quad (22)$$

For $x > 10$

$$\text{ber}\, x = \frac{e^{\delta}}{\sqrt{2\pi x}} \times \cos \gamma \quad (23)$$

$$\delta = \frac{x}{\sqrt{2}} + \frac{1}{8\sqrt{2}x} - \frac{25}{384\sqrt{2}x^3} \quad (24)$$

$$\gamma = \frac{x}{\sqrt{2}} - \frac{\pi}{8} - \frac{1}{8\sqrt{2}x} - \frac{1}{16x^2} - \frac{25}{384\sqrt{2}x^3} \quad (25)$$

For $0 \leq x \leq 10$

$$\text{bei}\, x = \frac{x^2}{2^2} - \frac{x^6}{2^2 4^2 6^2} + \frac{x^{10}}{2^2 4^2 6^2 8^2 10^2} + \ldots \frac{(-1)^{k+1} \times X^{4k-2}}{2^2 4^2 (4k-2)^2} \quad (26)$$

For $x > 10$

$$\text{bei}\, x = \frac{e^{\delta}}{\sqrt{2\pi x}} \times \sin \gamma \quad (27)$$

δ and γ are the same as before.

For $0 \leq x \leq 10$

$$\text{ber}'\, x = \frac{4x^3}{2^2 4^2} + \frac{8x^7}{2^2 4^2 6^2 8^2} - \frac{12x^{11}}{2^2 4^2 6^2 8^2 10^2 12^2} \ldots + \frac{(-1)^k \times 4k \times x^{4k-1}}{2^2 4^2 6^2 \ldots (4k)^2} \quad (28)$$

For $x > 10$

$$\text{ber}'\, x = \frac{e^{\eta} \cos \omega}{\sqrt{2\pi x}} \quad (29)$$

$$\eta = \frac{x}{\sqrt{2}} - \frac{3}{8\sqrt{2}x} + \frac{21}{128\sqrt{2}x^3} + \frac{27}{128x^4} \quad (30)$$

$$\omega = \frac{x}{\sqrt{2}} + \frac{\pi}{8} + \frac{3}{8\sqrt{2}x} + \frac{3}{16x^2} + \frac{21}{128\sqrt{2}x^3} \quad (31)$$

For $0 \leq x \leq 10$

$$\text{bei}'\, x = \frac{2x}{2^2} - \frac{6x^5}{2^2 4^2 6^2} + \frac{10x^9}{2^2 4^2 6^2 8^2 10^2} - \ldots \frac{(-1)^{k+1}(4k-2)x^{4k-3}}{2^2 4^2 \ldots (4k-2)^2} \quad (32)$$

For $x > 10$

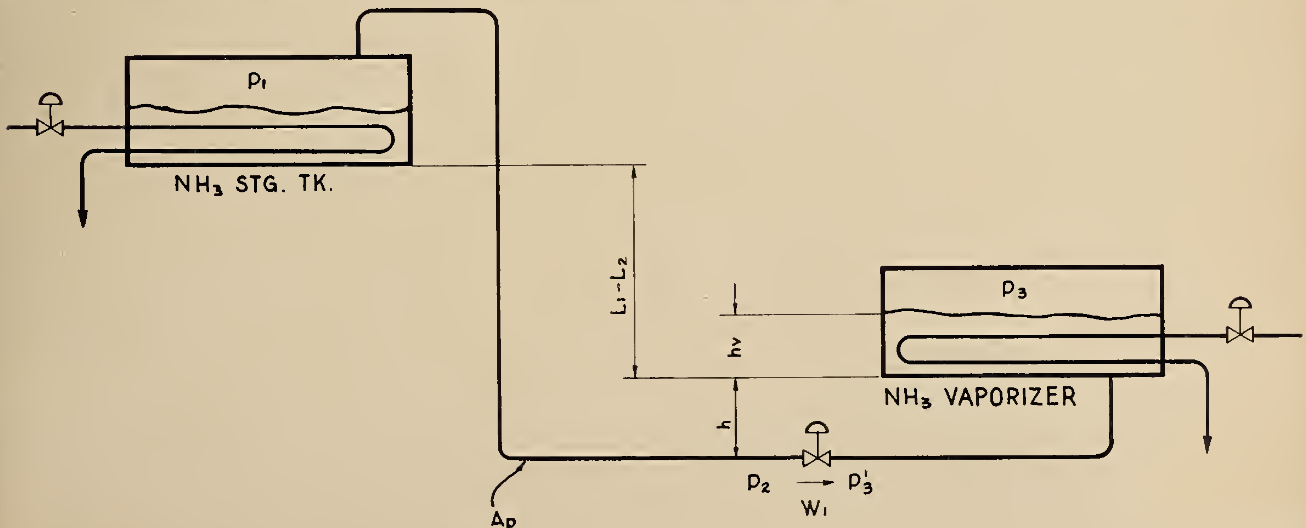
$$\text{bei}'\, x = \frac{e^{\eta}}{\sqrt{2\pi x}} \cdot \sin \omega \quad (33)$$

η and ω are as before.

Symbols

A	constant
a	radius of tube sheet over which hydrostatic pressure acts, in.
B	constant
b	(O.D. − I.D.)/2 of flange, in.
c	combined flange and tube sheet thickness, in.
D	flexural rigidity of tube sheet, in./lb. $D = Eh^3\eta_w/12(1 - \nu^2)$
d	tube outside diameter, in.
E	modulus of elasticity, p.s.i.
f	fraction of total tube sheet area on which pressure acts directly.
h	tube sheet thickness, in.
k	tube bundle modulus, lbs./in.^{3}
L	tube length, in.
M_r	radial bending moment, in.-lbs/in.
N	number of tubes in tube sheet
P	tube pitch, in.
p	pressure, p.s.i.
q	local effective pressure at radius r, p.s.i.
R	flange bolt circle radius, in.
r	tube sheet at radius r, in.

Fig. 12. Diagram of System from Ammonia Storage Tanks to Ammonia Vaporizer.



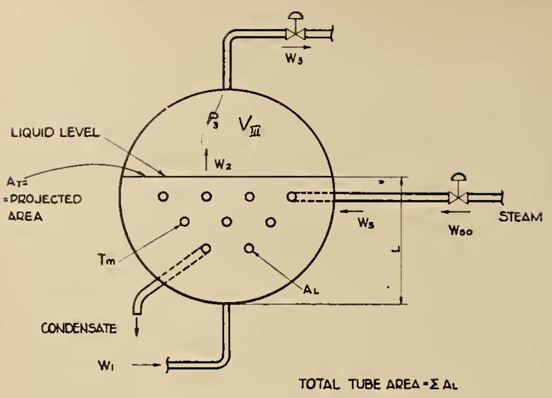


Fig. 13. Diagram of Ammonia Vaporizer.

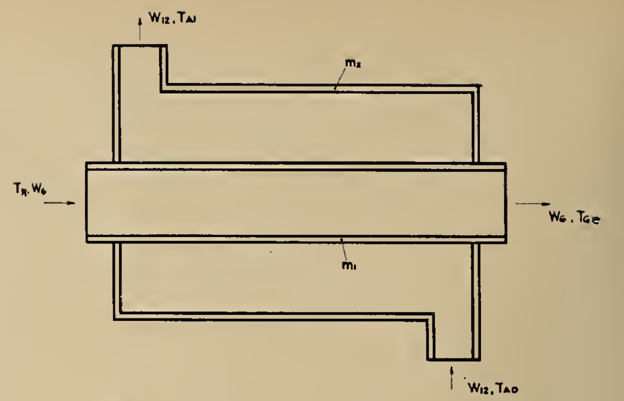


Fig. 14. Diagram of Heat Exchanger.

T	temperature, °F.
t	thickness (without subscript represents tube wall thickness), in.
W	loading, lbs.
w	tube sheet deflection, in.
x	$\beta \times \gamma$, dimensionless.
ber x	real part of Bessel function, $I_0(x\sqrt{i})$
bei x	imaginary part of Bessel function, $I_0(x\sqrt{i})$
ber′ x	$\frac{d\,(\text{ber}\,x)}{dx}$
bei′ x	$\frac{d\,(\text{bei}\,x)}{dx}$
α	linear coefficient of thermal expansion, in./in./°F.
β	$(2k/D)^{1/4}$, in.
η_w	$1 - \frac{3}{\pi}\sin^{-1}\left(\frac{d\sqrt{3}}{2P}\right)$
ν	Poisson's ratio
Θ_h	head slope at joint, radians.
Θ_r	tube sheet slope at radius r, radians.
Θ_s	shell slope at joint, radians.

Subscripts:

a	at periphery of tube sheet.
h	head
r	radial
s	shell
t	tube

Appendix II

Formulation of Mathematical Model of Nitric Acid Plant

The basic equations upon which simulation of the plant performance was established are as follows:

I. From ammonia storage tanks to ammonia vaporizer.

$$\frac{dW_1}{dt} = \frac{A_p}{KM_p}(P_1 - P_2) + \frac{k_1}{KM_p}(L_1 - L_2) - \frac{k_2 W_1^2}{KM_p} \quad (1)$$

$$K = \frac{1}{A_p \rho g}$$

M_p = liquid contained in the pipe—lbs.

$$W_1 = \gamma \cdot K_V \cdot \sqrt{P_2 - P_3'} \quad (2)$$

$$0 < \gamma < 1.0000$$

$$K_V = k_3 \cdot C_V \sqrt{1/G}$$

$$P_3' = P_3 + (h + h_V)\,k_4 \quad (3)$$

II. Ammonia vaporizer.

$$k_5\,A_T \frac{dL}{dt} = W_1 - W_2 \quad (4)$$

$$W_2 = \frac{(T_m - T_L)A_L U_L}{\lambda_L} \quad (5)$$

$$A_L = f_1(L) \quad ; \quad A_T = f_2(L) \quad (6)$$

$$\frac{dT_m}{dt} = (W_s\lambda_s - W_2\lambda_L)\frac{1}{C_{Hm}} \quad (7)$$

$$W_s = \frac{(T_s - T_m)A_L U_s}{\lambda_s} \quad (8)$$

$$T_s = f(P_s) \qquad 84 + 0.8P_s \quad (9)$$

$$\frac{dP_s}{dt} = \frac{(W_{s0} - W_s)K}{V_s} \quad (10)$$

$$T_L = f(P_3) \quad ; \quad 0.4P_3 - 30 \quad (11)$$

$$\frac{dP_3}{dt} = \frac{(W_2 - W_3)\cdot K}{V_{III}} \quad (12)$$

$$W_s = K_V \times \gamma_s \times P_{s0} \times f\left(\sqrt{\frac{P_s}{P_{s0}}\left(1 - \frac{P}{P_{s0}}\right)}\right) \quad (13)$$

$$0 < \gamma_s < 1.0000$$

III. Pressure Control Valve to determine W_3, W_4, W_5 (see Fig. 5).

$$W_3 = \gamma \times K_{V3}\sqrt{P_4(P_3 - P_4)} \quad ; \quad 0 < \gamma < 1.0000 \quad (14)$$

$$\frac{dP_4}{dt} = (W_3 - W_4)\frac{K}{V_{IV}} \quad (15)$$

$$W_4 = \gamma \times K_{V4}\sqrt{P_5(P_4 - P_5)} \quad ; \quad 0 < \gamma < 1.0000 \quad (16)$$

$$W_5 = K_{G5}\sqrt{P_5(P_5 - P_6)} \quad (17)$$

$$\frac{dP_5}{dt} = (W_4 + W_{11} + W_{12} - W_5)\frac{K}{V_v} \qquad (18)$$

IV. Reacted Temperature.

$$T_i = \frac{W_4 \times C_{PA} \times T + W_{11} \times C_{PA} \times T_{A0} + W_{12} \times C_{PA} \times T_{A1}}{W_4 C_p + (W_{11} + W_{12})C_{pA}} \qquad (19)$$

T_i = Temperature at entrance to the air-ammonia mixer, °C.

$$T_R = \left[\frac{7.06 + 2.37y'}{7.52 + 3.94y'}\right] T_i + \frac{y'Q}{7.52 + 3.94y'} - \frac{UA(T_R - T_m)}{C_{HG}} \qquad (20)$$

where Q = 54253 P.C.U./lb. mol. (at 18°C.)

T_m = metal temperature at reactor reaction zone' °C.

G_{HG} = heat capacity of gas contained within reaction zone, P.C.U./°C.

$$C_{HG}\frac{dTm}{dt} = UA(T_R - T_M) \qquad (21)$$

$$y' = y \times (\text{D.T.}) \qquad (22)$$

$$(\text{D.T.}) = \frac{\text{Designed Production Rate} = W}{\text{Actual Production Rate}} \qquad (23)$$

$$y = \frac{W_4}{W_{11} + W_{12} + W_4} \qquad (24)$$

V. Pressure-Volume Systems (see Fig. 5)

$$\frac{dP_6}{dt} = (W_5 - W_6)\frac{K}{V_{VII}} \qquad (25)$$

$$W_6 = K_6\sqrt{P_7(P_6 - P_7)} \qquad (26)$$

$$\frac{dP_7}{dt} = (W_6 - W_7)\frac{K}{V_{VII}} \qquad (27)$$

$$W_7 = K_7\sqrt{P_7(P_7 - P_8)} \qquad (28)$$

$$\frac{dP_8}{dt} = (W_7 - W_8)\frac{K}{V_{VIII}} \qquad (29)$$

$$W_8 = K_8\sqrt{P_9(P_8 - P_9)} \qquad (30)$$

$$\frac{dP_9}{dt} = (W_8 - W_9)\frac{K}{V_{IX}} \qquad (31)$$

$$W_9 = K_9\sqrt{P_{10}(P_9 - P_{10})} \qquad (32)$$

$$\frac{dP_{10}}{dt} = \left[W_{10} - (W_{11} + W_{12})\right]\frac{K}{V_x} \qquad (33)$$

$$W_{10} = K_{10}\sqrt{P_{10}(P_{12} - P_{10})} \qquad (34)$$

$$W_{11} = k_{11} \times W_{12} \qquad (35)$$

$$W_{12} = K_{12}\sqrt{P_5(P_{10} - P_5)} \qquad (36)$$

VI. Heat Exchanger. (See Fig. 14).

$$\frac{dT_{m1}}{dt} = \frac{2UA_1}{C_{H1}}(T_G - T_{m1}) + \frac{2UA_1}{C_{H1}}(T_A - T_{m1}) \qquad (37)$$

where C_{Hj} = metal wall heat capacity, P.C.U./°C.

$$\frac{dT_{m2}}{dt} = \frac{UA_2}{C_{H2}}(T_A - T_{m2}) \qquad (38)$$

$$T_G = \frac{T_R + T_{GC}}{2} \qquad (39)$$

$$T_A = \frac{T_{A1} + T_{A0}}{2} \qquad (40)$$

$$(T_{m1} - T_A)2UA + (T_{m2} - T_A)2UA = W_{12}C_{pA}(T_{A1} - T_{A0}) \qquad (41)$$

$$C_{pG}W_6(T_R - T_{Ge}) = 2UA(T_G - T_{m1}) \qquad (42)$$

Symbols

A	area, ft.²
C	specific heat, P.C.U./lb/°C.
C_H	heat capacity, P.C.U./°C.
C_V	valve flow coefficient
$D.T.$	Dead time, sec.
$f(\ )$	function
G	liquid sp. gr. or gas sp. gr. (air and water = 1.0)
g	gravitational acceleration, 32.16 ft./sec.²
h	height of liquid, ft.
K	RT—coefficient used in gas law.
K_{65}	flow coefficient through reaction zone.
K_V	valve coefficient $K_V = k \cdot C_V \cdot \sqrt{\frac{1}{G}}$
k	coefficient (conversion of units)
L	elevation above datum line, ft.
M	liquid weight, lbs.
P	pressure, lbs,/in.²
T	temperature, °C.
U	overall heat transfer coefficient, P.C.U./sq. ft./sec./°C.
$W_{1,2,\ldots n}$	mass flow, lbs./sec.
W	design production rate, tons/day.
V	volume, ft.³
y	ratio
γ	valve area compensation factor (linear valves)
λ	latent heat, P.C.U./lb.
ρ	density, lbs./ft.³

Subscripts:

A	air
e	end condition
G	gas
i	entrance condition
L	process liquid or level
m	metal
0,1,2 . . .	sequence of conditions in direction of flow at selected points.
p	pipe or pressure
R	reactor
S	steam
T	projected area

THE WARSAK HYDRO-ELECTRIC PROJECT

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Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

The purpose of this paper is to describe the Warsak Hydro-Electric Project, a joint Canada-Pakistan undertaking of the Columbo Plan. As the project is being constructed some 10,000 miles away in the Asian subcontinent, and under unusual conditions, it is proposed to describe the Colombo Plan operation, the area in Pakistan of the development, and finally the Warsak project itself.

ONE of the greatest developments in international affairs since the end of World War II has been the readiness of the countries of the western world to assist their less fortunate neighbours. The Colombo Plan, under which the nations of south and southeast Asia are striving to improve the health and welfare of their large populations, attempts to combine self-help with assistance from outside.

Emerging from a meeting of the Foreign Ministers of the British Commonwealth of Nations at Colombo in January, 1950, the Colombo Plan's original members were the United Kingdom together with its dependencies in Malaya and Borneo, Australia, Canada, Ceylon, India, New Zealand, and Pakistan. From the start, however, it was intended that additional countries should be invited to participate, and a number have since joined. Each of the underdeveloped members drew up a program of projects extending over an initial trial period of six years, and estimated the external assistance it would need. The assisting countries in turn pledged various amounts of capital and technical aid.

Two particularly valuable features of the Colombo Plan are that the assistance it offers is essentially for long-term benefit, and that it requires the active co-operation of both parties to the project. The Asian countries particularly appreciate participating in the program, rather than just having aid bestowed upon them.

Because of Canada's extensive experience in the design and construction of power development projects, these have figured prominently in the assistance that has been extended by this country. The Warsak Hydro-Electric Project is the largest capital aid program in Pakistan.

West Pakistan

The Islamic republic of Pakistan comprises two political entities, namely, the provinces of West Pakistan and East Pakistan.

West Pakistan, in which the Warsak project is located, is bordered on the southwest by Iran, on the west and north by Afghanistan, on the northeast by the disputed territories of Jammu and Kashmir, on the east and southeast by India, and on the south by the Arabian Sea. The key plan, Fig. 1, shows the location of West Pakistan relative to India and Afghanistan.

West Pakistan presents great variations in landscape and climate, from the snow covered peaks of the upper Himalayas to the grey, sombre desert of the Sind. In elevation, the country varies from the sea-level delta of the Indus to the mountainous peak of K-2 at elevation 28,250 ft. above sea level.

It goes without saying that the institutions, ideas, and beliefs extant in Pakistan are quite different from those in Canada. A genuine effort on the part of the foreign worker to understand and know the people of

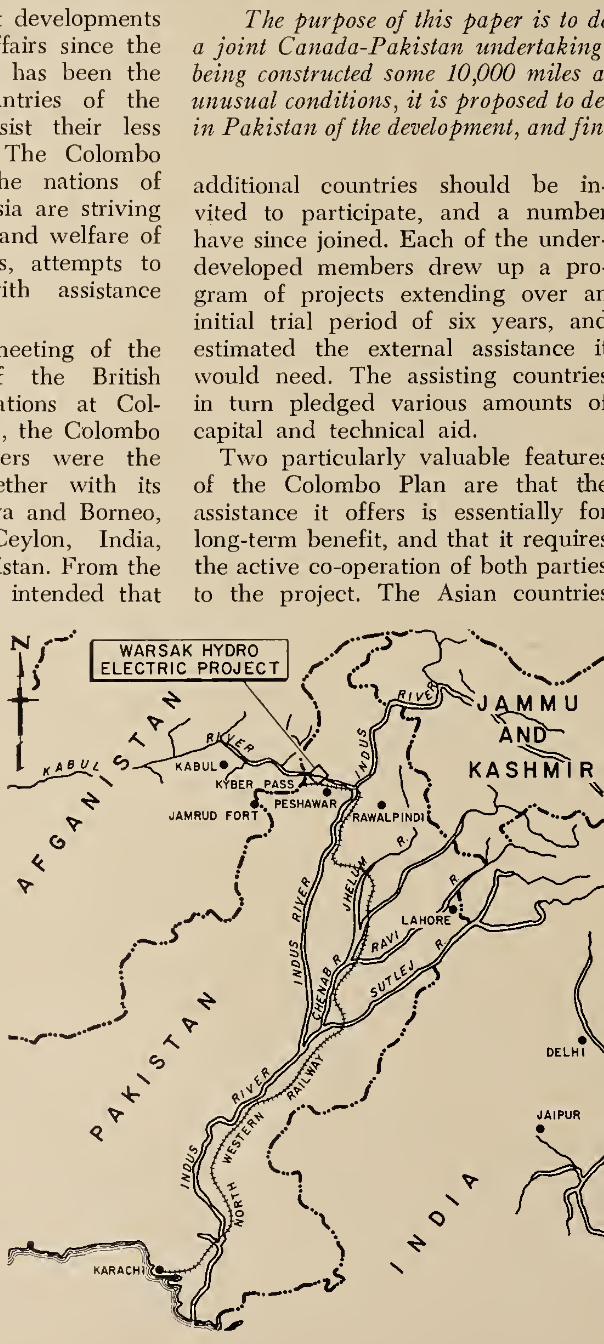


Fig. 1. Location of the Warsak Hydro-Electric Project.

the country is necessary and will go a long way to help him adjust himself to his new environment.

Early Consideration of Project

Consideration of a possible hydro-electric project on the Kabul River was initiated by a note dated August 28, 1948, written by Colonel J. R. Hainsworth, C.B.E., R.E., then the Chief Engineer and Secretary to Government, North-West Frontier Province.

Since then various preliminary reports were prepared until finally in 1952, after the inception of the Colombo Plan, assistance under the Plan was requested from Canada in respect of several hydro-electric proposals, including the Warsak project. As a result, Messrs. J. H. Ings and F. W. Patterson of H. G. Acres & Company Limited visited Pakistan and India in the fall of 1952, inspected the sites, and gathered data.

The Warsak project was among those recommended for inclusion in the program of Colombo Plan assistance. Subsequently formal approval was given and our consulting engineering firm was appointed by the Canadian government to design the structures and supervise construction. Shortly afterwards a general contract for the civil contract was negotiated. An agreement between the Governments of Pakistan and Canada was negotiated, setting out the scope of participation of each of the countries and the responsibilities and services to be undertaken by the consulting engineers and the general contractors.

Location and General Description

The site of the project is on the Kabul River, approximately 19 miles northwest of Peshawar, and 15 miles from Jamrud Fort, the nearest railroad station of the North Western Railway.

The Kabul River rises in north central Afghanistan, and provides drainage for the eastern portion of that country. Through one of its tributaries it also drains the state of Chitral in northern Pakistan. The total drainage area above the Warsak dam site is approximately 26,000 sq. miles.

Kabul, the capital city of Afghanistan, is situated on the river, about 60 miles from the source. From Kabul the river flows eastward, dropping several thousand feet in elevation into the Jalalabad valley and thence to the border between Afghanistan and Pakistan. The river then twists and turns through the hills of the Sofed Koh Range, then flows mainly eastward until it debouches on to the flat land of the Vale of Peshawar at Warsak Head.

The elevation of the low water level of the river at the Afghanistan border is 1267 ft. above mean sea level, and at Warsak the corresponding elevation is 1118 ft. The fall of the river between these two places is therefore 149 ft. over a distance of 26 miles, or an average slope of 5½ ft. per mile. In this reach the river flows in a gorge whose banks rise steeply to several hundred feet above the river level. At intervals the banks are cut by deep ravines or nullahs. The width of the river varies between 200 and 300 ft. at high water level.

The normal headpond level is at elevation 1269 ft., and allows for a 10 ft. pondage drawdown. These elevations are well below the existing maximum high water levels at the boundary, and so river conditions within Afghanistan should not be affected by the development of the power reach located wholly within Pakistan.

The initial development will comprise four generating units of 40,000 kw. each, but the power tunnel, penstocks and powerhouse are being constructed for the future installation of two more similar units. In addition, there will be two small house-units of 750 kva. each which will give service power for running the various auxiliary equipment, lighting, and the operators' colony. The main dam will be a concrete gravity structure some 200 ft. high, completely closing the gorge of the Kabul River.

The project will be provided with a 10 ft. diam. irrigation tunnel 3.5-miles long. This will allow the irrigating of 100,000 acres of the Peshawar plains around Jamrud Fort. This part of the project will provide an opportunity to settle many of the hill tribe families on useful productive lands and will thereby enhance the stability of the whole area.

Geology and Foundations

Since the first investigations were started at Warsak in early 1949, extensive geological investigations have been carried out. In all some 148 holes were drilled, varying in diameter from 1¾ in. to 22 in. Over and above this exploratory drilling some 1800 ft. of exploratory tunnel were driven into the south bank.

General Geology:

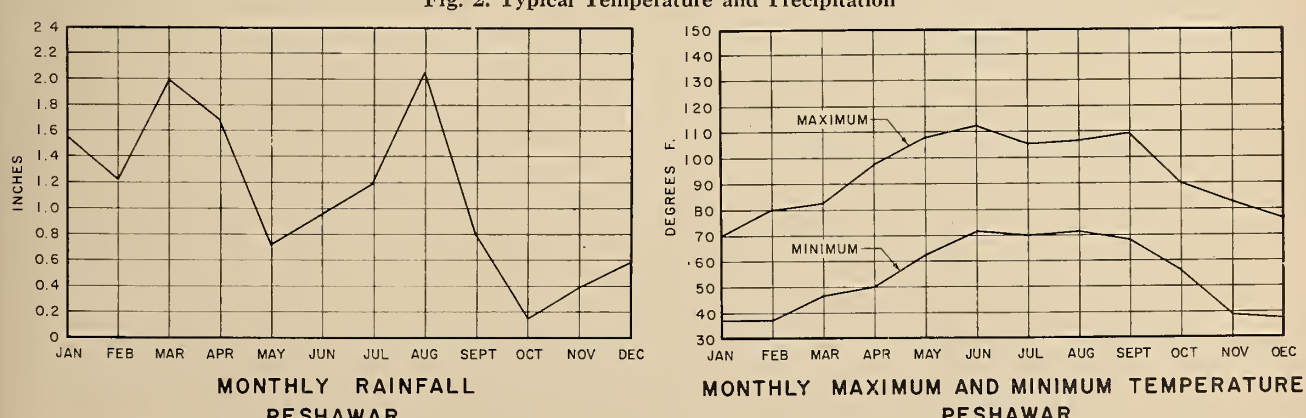
The project is wholly in an area of metamorphic schists and gneisses. The following local succession has been established:

5—Superficial deposits, river gravel and boulder beds, high level terrace deposits and talus.
4—Phyllite group 500 ft. + thick
3—Upper granite gneisses 450 ft. thick
2—Multiple schists 90 ft. thick
1—Lower granite gneisses 600 ft. thick

1—Lower Granite Gneisses—This group is characterized by a persistent upper zone of decomposed gneiss 5 to 15 ft. thick. A faulted and decomposed belt 50 to 100 ft. long outcrops at the diversion tunnel inlet.

2—Multiple Schists—The lower granite gneisses are succeeded by 90 ft. of alternating acid and basic micaceous schists. These schists form an impervious barrier beneath the dam.

Fig. 2. Typical Temperature and Precipitation



3—Upper Granite Gneisses—These are hard, medium grained, whitish gneisses. A conspicuous foliation dips uniformly northeast at 45°, but does not represent a structural weakness in the rock. The principal jointing and some faulting follows this direction. Two other main joint sets are found:

(a)—Joints striking to the northeast and dipping mainly to the northwest at 70° to 80°, but locally to the southeast at 70° to 90°.

(b)—Joints striking northwest and dipping southwest at 40° to 70°.

4—Phyllite Group—This group includes phyllites, phyllitic quartzites and some marbles. These are softer rocks and have been eroded in many places to form nullahs.

Some basic dykes are present which are folded. They do not follow closely the structure of the schists and gneisses. These dykes are of significance because they hold up pockets of water in the overlying granites which facilitates rock slides. The two rock slides behind the powerhouse were probably caused by this condition.

Structure:

The principal structure is a syncline plunging northeast with its axis intersecting the east-west line of the Kabul River downstream from the damsite. The boundaries of the various rock types are cut at right angles by the river. The boundaries, the foliation, the schistosity, and the principal joints all dip downstream at 45° to the east-northeast.

The river line does not correspond to any significant fault movement in the area. A number of small earthquakes are experienced each year and apparently originate outside the area.

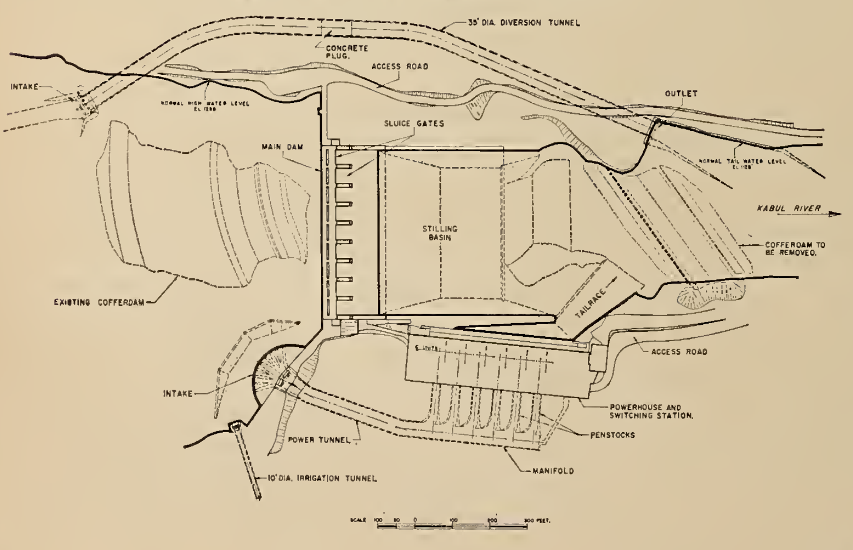
Hydrology

Climate: The Asian subcontinent in general is subject to a monsoon type of climate. During the winter months a high barometric pressure builds up over central China and Siberia, causing air movement from the continent towards areas of low pressure over the Indian Ocean and Indonesian Archipelago. The cold air masses flowing south over India and Pakistan are necessarily dry. Whatever moisture might have been present originally is lost as the air moves over the Himalaya Mountains. Thus, the winter may be expected to be the dry season in which very little or no rainfall occurs south of the Himalayas.

During the summer the barometric pressures over the Asiatic continent drop as the temperature rises and the air flow is reversed. Air masses, originating from the area of the Indian Ocean and having a high moisture content, travel in a northwesterly direction over India and Pakistan, gradually losing their moisture until they strike the Himalayan Mountains where the remaining moisture is shed. The air arriving over Burma and East Pakistan has travelled a longer distance over the oceans than, say, the air arriving over West Pakistan, and has, therefore, a higher moisture content.

As a result the general climate varies from very humid in East Pakistan (80 in. at Dacca) to subhumid in West Pakistan (16 in. at Peshawar). Afghanistan, which contains the greater part of the Kabul River watershed, is shielded from the sea by high mountain ranges which further reduce rainfall, giving a semi-arid climate. The temperatures vary within wide limits, as is typical for a continental climate.

Fig. 3. General Arrangement of Project



While the greater portion of the moisture-laden monsoon winds travel in a northwesterly direction, nevertheless there is a lesser monsoon wind that approaches India from the southwest. This is caused by a deflection of the general monsoon winds by pressure conditions over the Arabian Sea. The result is high precipitation from the Gulf of Kutch down to the Malabar Coast.

Many other local conditions affect the monsoon distribution, with the end result that the Sind area of West Pakistan has practically no rain and the remaining part of the monsoon moisture that reaches the Rawalpindi-Attoc area is deflected north.

The discussion in the preceding paragraphs, while explaining the type of climate over most of West Pakistan, does not cover the Warsak-Peshawar area. Over this zone the wind directions differ from the rest of the monsoon-covered area and, in addition, there are two distinct rainy seasons, one in the early summer and one in the winter. It is quite possible that this variation from the typical monsoon climate of the sub-continent may be caused by Mediterranean pressure variations which do affect neighbouring Iran and Afghanistan.

Temperature changes in the Warsak-Peshawar area show continental changes from highs of 120°F in the summer to lows of 25°F in the winter. Typical precipitation and temperatures are shown on Fig. 2.

Hydrograph of the Kabul River: The Kabul River and its tributaries, the Kunar (sometimes called the Chitral), the Alingar, the Pansjir, the Logar, and the Sarkhab, drain an area of approximately 26,000 sq. miles. This drainage area, located entirely in Afghanistan except for some 5800 sq. miles in Pakistan on the upper Kunar, is surrounded by high mountains on all sides, the narrow gorge extending through the Safed Koh Range from the Jalalabad valley to Warsak being the only low level outlet. The mountain ranges to the north, part of the Hindu Kush, rise to elevations of the order of 20,000 ft. and have permanent snow fields at the higher elevations.

These mountains are tertiary formations as are the Alps in Europe and the Rocky Mountains of North America. Because of the general sparseness of vegetation, soil and loose decaying rock are easily eroded. Consequently, little overburden exists on the rock hills and mountains of the catchment area and alluvial deposits are confined to stretches of flat river valleys where the rivers lose their bed-load carrying capacity. The

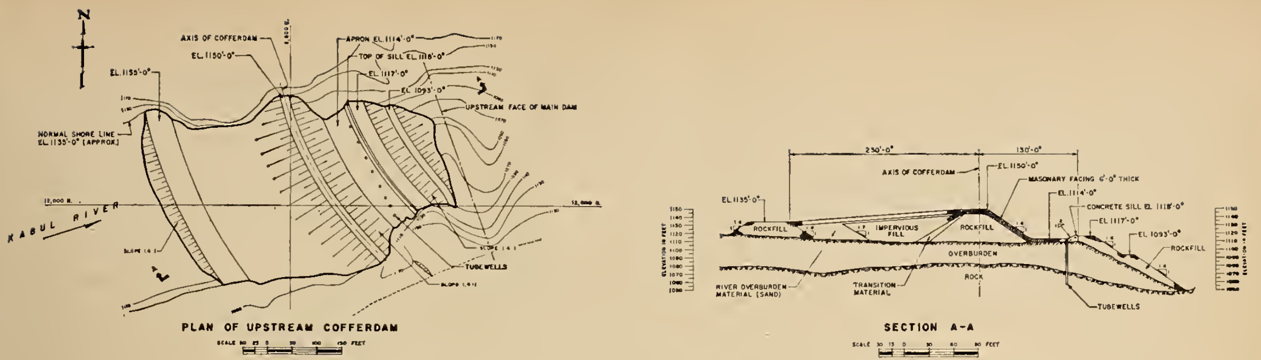


Fig. 4. Upstream Cofferdam — Plan (left) and Section (right)

catchment area will, therefore, probably have little underground storage either in overburden or in rock.

The shape of the hydrograph of the Kabul River shows the following features:

(a)—Between March 1 and April 1 the discharge of the Kabul River increases from a minimum to a maximum which will occur on the average in June or July.

(b)—During August and September there is a sharp decrease in discharge.

(c)—From October to March the flow falls to a low value which is nearly constant each year.

This distribution of the runoff over the year is in general agreement with the climatic conditions as described for Afghanistan and the North West Frontier region. The extent and rate of the spring flood flows is governed by snow melt and temperature conditions in the mountains rather than by monsoon conditions which govern the major rivers of India and East Pakistan.

As the catchment area is generally rock with little vegetation and with no lakes, any precipitation is immediately reflected in the hydrograph. Individual rainstorms appear as sharp peaks. It is not unusual to see rain storms raise the river stage at Warsak by 3 to 5 ft. in a matter of a few hours. The Kabul River flow records are based on gauge readings which have been taken at Warsak Head since 1900.

The bed of the river at Warsak Head is not stable. When the river flow increases, erosion occurs and causes a considerable movement of the bed materials. As the flow decreases, material is deposited in the river bed, especially just downstream from Warsak Head where the river emerges from the gorge and flows through an unstable multichannel section before continuing as a single channel to the Indus.

Since the river bed is unstable, only those water levels recorded during the actual period of discharge measurements may be related directly to the above-mentioned discharge rating curve. Therefore, early investigators adjusted the recorded water levels at Warsak Head to allow for the changes in the river bed and, by means of the discharge rating curve, estimated the river discharge for the period 1900 to 1950. A duration curve of river discharge was prepared on the basis of these estimated discharges.

For the purpose of estimating the magnitude of probable flood discharges, early investigators plotted a probability curve on the basis of the estimated maximum annual discharge during the period 1900 to 1950. This curve was extrapolated to cover the range of flood magnitudes far in excess of those recorded during the 51-yr. period in an attempt to indicate the frequency at which these higher discharges might be expected. From this probability curve the magnitude of floods which might occur *on the average* once in 100 yr., once in 1,000 yr., and once in 5,000 yr., were noted.

While the methods of adjustment of records used by the early investigators are considered reasonable within the range of actual discharge measurement, it is also thought that extrapolation of the derived data to high flood ranges could only be considered a very rough approximation.

Several types of frequency curves were plotted and adjusted and the whole considered with a somewhat sceptical and conservative eye. The safety aspect of flood is of prime importance in any decision or choice of design, and in the design of a dam it includes consideration of the safety of the structure itself, of the life and property endangered by its failure, and consideration of the economic consequences of a failure.

The investigations and studies led to a choice of the following four floods:

(a)—A flood of 28,000 c.f.s. through the diversion tunnel during construction and with no flow over the cofferdams.

(b)—A flood of 200,000 c.f.s. during construction, partly through the diversion tunnel and partly over the cofferdams.

(c)—A flood of 320,000 c.f.s. through the completed dam sluice gates, and without flooding into Afghanistan beyond normal flood levels.

(d)—A super flood or maximum design flood of 540,000 c.f.s. This would involve some flooding in Afghanistan and raising the water levels at the Warsak powerhouse to the draft tube exit deck.

Storage and Flow

The watershed of the Kabul River is completely devoid of lakes that would provide a measure of natural storage or which could be developed to provide cheap artificial storage. Because of the rocky mountainous character of the watershed, the low, flat, wide valleys that exist and which might be developed for storage at reasonable cost, are highly developed agriculturally and could not be converted to other uses without serious adverse economic and political effects.

Also it must be noted that 20,000 out of 26,000 sq. miles of catchment area are in Afghanistan and not Pakistan. This means that any storage that could or would be developed in Afghanistan would be in a foreign country and would be a subject for international treaty and not under Pakistan control.

At Warsak the headpond of the development extends to the Afghan border but lies in a mountain gorge over its entire length. When allowances are made for dead storage, siltation, etc., the gross volume of 62,000 acre-feet is reduced to a useful live storage volume of about 20,000 acre-feet. This volume of pondage will allow for any reasonable daily or weekly load factor for peak discharges up to and exceeding 24,000 c.f.s., but is insufficient for any seasonal storage.

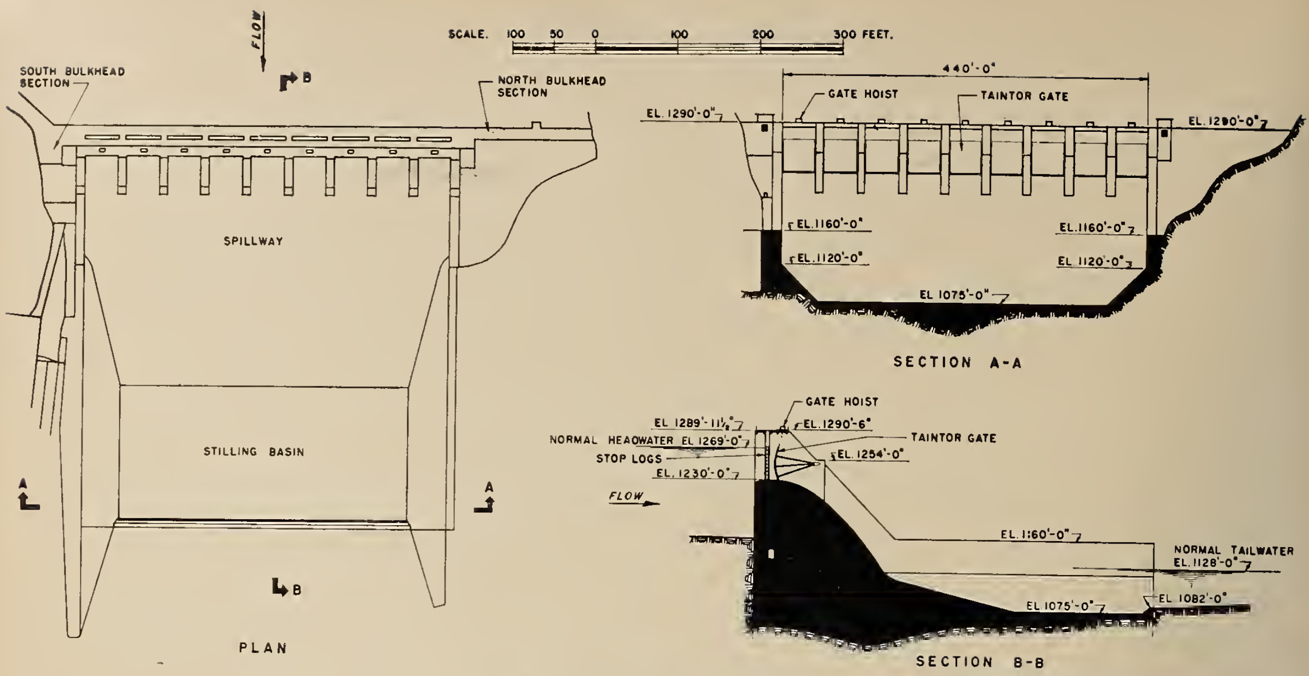


Fig. 5. Main Dam—Elevation and Section

Discounting the development of storage at upstream sites, for the immediate future at least, the following flow conditions pertain:

(a)—The minimum recorded flow in the Kabul River is 4180 c.f.s.

(b)—The minimum recorded 7-day average is 4380 c.f.s.

(c)—The minimum 28-day average is 4800 c.f.s.

(d)—The maximum recorded flow in the Kabul River is approximately 200,000 c.f.s. It is thought, however, that one year when the gauge was lost the flood discharge may have reached a figure of the order of 225,000 c.f.s.

A flow duration curve for the Kabul River, plotted from the records of the past 50 yr. follows:

Flow Equalled or Exceeded	*Percentage of Time*
24,000 c.f.s.	34
16,000 c.f.s.	44
12,000 c.f.s.	50
10,000 c.f.s.	55
8,000 c.f.s.	63
7,350 c.f.s.	70
7,000 c.f.s.	86
6,000 c.f.s.	95.5
4,180 c.f.s.	100

Power

Four hydraulic turbine-generating units are installed and provision has been made for the future installation of two more. Each vertical 55,000 hp. reaction turbine is coupled to a 40,000 kva. vertical water-cooled generator.

The 160,000 installation will be able to maintain power output at 100% daily load factor, in accordance with the following power duration curve:

Power Equalled or Exceeded	*Percentage of Time*
160,000 kw.	15
150,000 kw.	35
140,000 kw.	44
120,000 kw.	52
100,000 kw.	57
80,000 kw.	68
74,000 kw.	85
70,000 kw.	90
63,000 kw.	95
46,000 kw.	100

In an average year this installation could produce, at 100% daily load factor, 1,010,000,000 kwh. A fifth 40,000-kw unit could produce an additional 130,000,000 kwh; a sixth unit an additional 100,000,000 kwh.

Most of the network load will probably be a tubewell pumping load, that could be curtailed without damage to crops. It would seem reasonable to consider 6,000 c.f.s. (available or exceeded 95% of time) as the practical minimum flow. Also, as West Pakistan develops industrially the network load factor probably will change. It is of interest, then, to indicate the firm peak output at various load factors, again on the basis of four units of 40,000 kw. each.

Load Factor Percentage	*Firm Peak Output kw.*
100	60,000
90	67,000
80	75,000
70	86,000
60	100,000
50	120,000
46.5	129,000
41.8	143,000
40	150,000
37.5	160,000

With regard to future expansion of the Project, consideration of the preceding paragraphs on storage, flow and power appears to indicate that:

(a) While development of storage on the watershed could substantially raise the level of minimum firm power, it is not likely to be available in amounts that would influence the installation of units 5 and 6.

(b) The future installation of units 5 and 6 could be carried out at reasonable cost, but would only be justified by the growth of a substantial demand for secondary power.

(c) The future installation of units 5 and 6 might be justified by the future growth of the thermal stations to a level that would allow the availability of summer excess flows to reduce the thermal fuel requirements which are either imported or a depleting natural resource.

Model Studies

The location of the Warsak project in a narrow river valley or gorge created many site problems. Not the least of these was the handling of large volumes of water through a very constricted area under various limiting conditions.

Side Channel Spillway Model: This model (scale 1:100) was constructed during the preliminary examination of the project to test the practicability of a side channel spillway having a discharge capacity of 540,000 c.f.s. The spillway formed a part of a layout utilizing a rock-fill dam. Conditions of approach, of flow in the spillway channel, and of discharge into the river were examined.

As a result of the tests conducted, it was found that there would be a serious erosion problem at the toe of the dam, and that the depth of flow at the channel outfall would be great enough to prevent effective stilling action downstream.

Concrete Overflow Spillway Model: A general model (scale 1:132) was essential in the final design of the Warsak project. This particular model reproduced the concrete dam, the spillway, stilling basin, powerhouse and tailrace, and the river channel for a distance of some 4,000 ft. downstream. Many tests were carried out, many revisions made, and alternatives studied.

The tests on the overall project model indicated the conditions, both upstream and downstream, under which the spillway could pass approximately 540,000 c.f.s. In addition, the same study set the physical characteristics of the stilling basin just downstream from the dam.

The model allowed an accurate determination of the rating curve downstream from the stilling basin and powerhouse so that only the minimum freeboard was required for the tailrace and transformer deck located above the draft tube outlets. Studies of this model also helped to reduce the amount of excavation required downstream from the stilling basin and indicated a layout which would keep the tailrace channel substantially free from harmful wave action and its outfall free from blockage by material carried downstream. At one critical river constriction, the model studies indicated the extent and depth of excavation that would be required when the project was completed and a workshop located in this area could be dismantled. The studies of flow in the river downstream from the dam showed that substantial dumping areas could be made available, and that dumping in these areas would result in a considerable saving in the cost of hauling excavated materials.

Diversion Tunnel Inlets and Outlets: These models were built at scales of 1:48 and 1:72, and were made up to establish the most economical form of excavation at the inlet and outlet areas, and the percentage of recovery of head which might be expected at the outfall. The tests at the inlet were made to establish inlet losses and flow conditions, all of which could affect the upstream cofferdam. These tests resulted in considerable economies being made in excavation and also allowed the calculation of a diversion tunnel rating curve.

Tailrace Model: Tests on the tailrace model (1:40) were made to establish whether there was any hydraulic advantage in skewing the draft tube outlets and also to find the minimum width of tailrace channel which was hydraulically acceptable.

The tests showed that 0.6 ft. of head could be saved by skewing the draft tube outlets and that, by tapering the width of the tailrace, considerable excavation economics could be effected behind the powerhouse. These features were of course incorporated in the final design.

Cofferdam Model: A fairly comprehensive set of tests was carried out on cofferdam models (1:57) to determine the extent of protection which would be required to prevent erosion of the cofferdams upstream and downstream from the main dam area when they were overtopped during the spring floods. A considerable saving in time and costs could be achieved if a design could be produced which would allow such overtopping. The period for construction in the river is limited to about six months a year on the average, and any time saved would be a worthwhile gain if the river construction seasons could be limited to two. The tests carried out showed that, unless the concrete of the main dam could be raised well above the river bed before the spring floods, the downstream face of the upstream cofferdam would have to be protected by 6 ft. of masonry. The tests also showed that, although erosion of the downstream cofferdam would not be severe, it should never-

FIG. 6 MAIN DAM—SPILLWAY TYPICAL TABULATION OF DESIGN COMPUTATIONS

	Unit	BASE ELEVATION OF SECTION								
		1210	1190	1170	1150	1130	1110	1090	1070	1050
Water Level to Base	Ft.	59	79	99	119	139	159	179	199	219
Top of Dam to Base	Ft.	80	100	120	140	160	180	200	220	240
Increase in Base	Ft.	—	23	18	15	13	14	49	—	—
Base Width	Ft.	79	102	120	135	148	162	211	211	211
Water Pressure—P1	Kips	5,450	9,750	15,320	21,700	29,620	38,800	49,200	60,750	75,000
Moment	Ft. Kips	107,000	257,000	505,000	860,000	1,371,000	2,060,000	2,930,000	4,032,500	5,480,000
Uplift Pressure	Kips	4,860	8,400	12,400	16,750	21,400	30.000	41,415	50,215	59,115
Moment	Ft. Kips	275,000	571,000	992,000	1,507,500	2,110,000	3,080,000	4,810,500	6,585,800	7,395,800
Silt Pressure—P2	Kips	165	660	1,485	2,640	4,130	5,940	8,090	10,560	13,350
Moment	Ft. Kips	1,320	10,550	35,500	84,000	165,000	285,000	452,000	679,000	961,000
Total O/T Moment	Ft. Kips	383,320	838,552	1,532,500	2,451,600	3,646,000	5,425,000	9,492,000	11,947,500	14,491,000
$\Sigma P = P1 + P2$	Kips	5,615	10,410	16,805	24,339	33,750	44,234	56,235	70,251	87,295
C of G above Base	Ft.	19.2	25.6	32.1	38.8	45.5	53.0	41.6	76.5	81.1
Concrete Weight	Kips	14,973	29,763	45,868	64,355	84,899	107,343	137,397	167,997	198,597
Moment	Ft. Kips	679,700	1,792,250	3,385,700	5,390,870	7,816,180	10,788,180	19,238,045	22,488,045	25,718,045
Headwater Weight	Kips	2,925	2,920	2,925	2,925	2,925	2,925	2,925	2,925	2,925
Moment	Ft. Kips	196,000	263,000	316,000	360,000	398,000	436,000	582,500	582,500	582,500
Tailwater Weight	Kips	—	—	—	—	—	506	1,055	1,055	1,055
Moment	Ft. Kips	—	—	—	—	—	3,036	21,800	42,980	64,200
Tailwater Pressure	Kips	—	—	—	—	—	366	3,360	3,360	3,360
Moment	Ft. Kips	—	—	—	—	—	1,585	71,700	71,700	71,700
Total Resisting Moment	Ft. Kips	875,700	2,055,250	3,701,700	5,750,870	8,214,180	11,228,801	19,934,045	23,185,225	26,436,445
FS against Overturning		2.27	2.45	2.42	2.34	2.25	2.07	2.10	1.94	1.83
ΣW	Kips	13,038	24,288	36,393	50,533	66,424	80,634	94,982	117,782	139,482
C of G of ΣW from Toe	Ft.	46.0	61.0	74.5	83.8	92.1	101.0	144.0	135.5	131.5
Tan $\varnothing = \frac{\Sigma P}{\Sigma W}$		0.431	0.428	0.463	0.481	0.508	0.548	0.593	0.596	0.625
ΣWXC (Take C = 0.65)	Kips	8,460	15,800	23,600	32,900	43,100	52,500	61,600	76,500	90,700
BRs where Rs = 400 P.S.I.	Kips	228,000	290,000	346,000	389,000	426,000	467,000	608,000	608,000	608,000
Shear Friction Factor—Sf $= \frac{\Sigma Wc + BRs}{\Sigma P}$		42	29	22	17	14	12	12	10	8
Location of Resultant from Toe	Ft.	37.8	50.0	58.3	65.0	68.8	72.0	110.0	95.6	85.5
Unit Vertical Stress—Toe	Kips/Sq. Ft.	4.7	5.0	5.9	7.9	10.3	12.5	14.5	17.9	19.8
Unit Vertical Stress—Toe	P.S.I.	32	34	41	55	71	87	101	124	138
Unit Vertical Stress—Heel	Kips/Sq. Ft.	3.6	4.6	6.2	7.1	7.7	7.4	6.9	6.3	6.7
Unit Vertical Stress—Heel	P.S.I.	25	32	43	50	54	51	48	44	46
Maximum Principal Stress at Toe—Compression	P.S.I.	109	64	67	80	104	132	183	229	258
Maximum Principal Stress at Toe—Shear	P.S.I.	55	32	34	40	52	63	86	106	118
Maximum Principal Stress at Heel—Compression	P.S.I.	42	55	72	85	94	97	100	102	110
Maximum Principal Stress at Heel—Shear	P.S.I.	8	10	14	17	17	14	11	8	7

theless be protected by concreting the top 18 in. of rock fill.

It may be added that the cofferdams under flood conditions were twice overtopped safely and exactly as planned.

General Arrangement

The early investigation and field studies were carried out by Merz Rendel Vatten (Pakistan) Ltd. They submitted reports in 1949 and 1951 and recommended an underground powerhouse and a 235 ft. high rock-fill dam. The rock-fill dam was to have had curved chute spillways at either end and a downstream berm was to accommodate an outdoor switching station.

As an alternative MRV(P) Ltd. suggested a 230 ft. high concrete dam with a surface powerhouse at the toe.

Subsequently H. G. Acres & Company Limited investigated five alternative schemes and estimates of relative costs and construction periods were prepared. These were:

Scheme A—Rock-fill dam and under- ft. diam. diversion tunnels, one side channel spillway. This was essentially the arrangement proposed by MRV (P) Ltd. in 1951.

Scheme B—Rock-fill dam and surface powerhouse, three 50 ft. diam. diversion tunnels, one 35 ft. diam. power tunnel, one side channel spillway.

Scheme C—Concrete gravity type dam and underground powerhouse, one 35 ft. diam. diversion tunnel, overfall spillway controlled by nine sluice gates.

Scheme D—Concrete gravity type dam and surface powerhouse downstream from dam, one 35 ft. diam. diversion tunnel and one 39 ft. diam. power tunnel, overfall spillway controlled by sluice gates.

Scheme E—Concrete gravity type dam, with integral surface powerhouse at the toe. One 35 ft. diam. diversion tunnel. Two chute spillways on either bank of the river.

As a part of the project common to all the schemes, the south bank contained a 3.5 mile long, 9 ft. diam. irrigation tunnel, this tunnel to feed a canal system to irrigate approximately 100,000 acres of arid but fertile plain in the Vale of Peshawar.

Scheme E did not offer any financial advantage, but did appear to have several disadvantages compared with the other schemes. It was therefore not considered any further.

Finally Schemes A, B, C and D were presented, through the Colombo Plan Administration, to the Government of Pakistan, Scheme D being recommended. This scheme is shown on Fig. 3, 5 and 8.

Early in January 1955 the Government of Pakistan approved Scheme D, and the design and construction proceeded on this basis with minor variations. From an engineering viewpoint, Scheme D is fairly straightforward. Flood waters are handled efficiently, diversion is relatively simple and the powerhouse work can proceed independently of conditions in the river bed.

Diversion

In the construction of most hydroelectric schemes one of the contractor's major problems is unwatering the site.

At Warsak any unwatering scheme was hedged about with vexing problems:

(a)—The rock is poor and badly jointed;

(b)—The gorge is narrow;

(c)—The overburden in the river was known to extend to depths of 40 ft.;

(d)—The river is very "flashy";

(e)—The time to do work;

(f)—It was necessary either to overtop the cofferdams or replace them over two or three flood periods.

In order to render construction virtually independent of river flow conditions, three diversion tunnels, each 50 ft. in diam. inside the concrete lining, would have been required. The cost was estimated at $15 million based on 1954 prices. For a project with an earth core rock-fill dam, this procedure would have been necessary to avoid the hazard of overtopping and washing out the partially completed dam. For a concrete dam the situation is entirely different. Under such circumstances the flood waters can safely be passed through the partially constructed dam and the cofferdams either overtopped or replaced. The only diversion capacity required would then be the flow during the working season in the river.

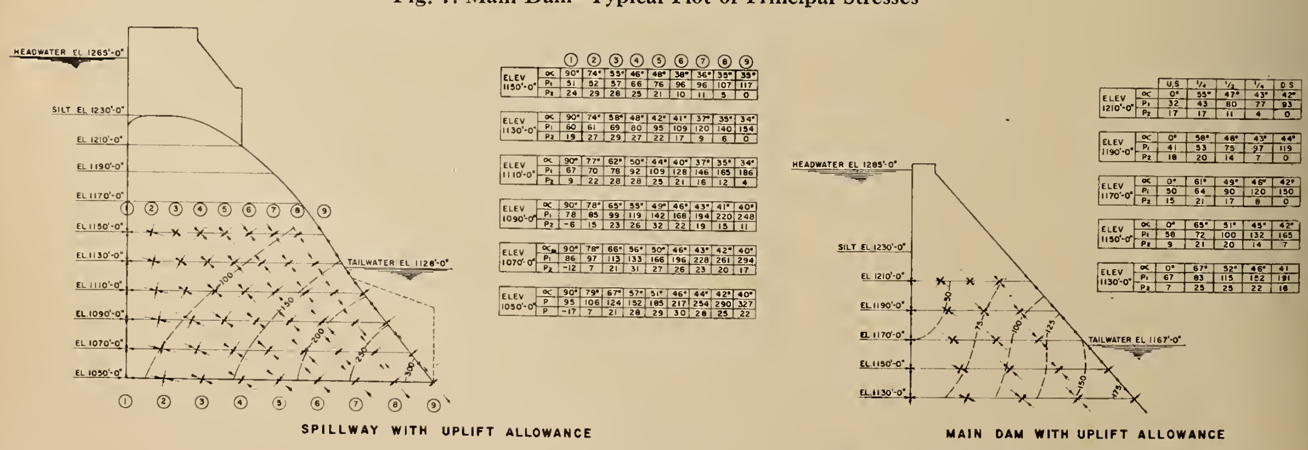
The costs associated with complete unwatering, the hazard of overtopping the unfinished dam, and the extended schedule, were the principal factors which led to the adoption of Scheme D.

Diversion Tunnel: As shown on Fig. 3. the unwatering scheme consists of one diversion tunnel with three earth and rock-fill cofferdams. This diversion tunnel was nominally of 35 ft. diam.

From portal to portal the diversion tunnel is approximately 1700 ft. long. In addition, the open-cut inlet and outlet channels are each several hundred feet long. Except for the transition section at the inlet, the tunnel was driven from the outlet end. The rock throughout was of quite poor quality; it was necessary to use 8 in. steel sets at 4 or 6 ft. spacings over the entire tunnel length.

The concrete tunnel lining was placed with the use of travelling steel forms supplied by Blaw-Knox. First the invert was placed using transit-mix trucks, then the side and arch concrete was placed by pumpcrete methods. A very smooth surface finish was obtained, but it was necessary to grout the crown of the arch to fill the inevitable voids

Fig. 7. Main Dam—Typical Plot of Principal Stresses



that occur at this point.

Before the lining was placed, a grout cut-off curtain was established completely around the tunnel perimeter. This curtain was so located as to be continuous with and form a part of the main dam grout curtain. It is also at the location of the permanent concrete plug that finally blocks the tunnel. Closure of the diversion tunnel is effected by steel head gates operated from a concrete tower above the tunnel intake. Two closure gates are used and their hoists are located on the tower deck at elevation 1257. The gates will be salvaged after use and one of them adapted for use as the permanent head gate of the irrigation tunnel on the south bank of the river.

Cofferdams: There are three main cofferdams. Two of these are in the river bed enclosing the area of the dam and stilling basin. The third is located parallel to the river and permits the uninterrupted construction of the powerhouse.

This powerhouse cofferdam was constructed of earth and rock fill with the top or crest at elevation 1155. This fill rests on overburden which in turn overlies jointed rock. A grout curtain was established in the overburden and to some depth in the rock. That this has been very successful was evidenced by the small amount of seepage into the powerhouse excavation.

As mentioned earlier, the river cofferdams have been designed to be overtopped by the annual floods. Many special problems resulted from this decision which could only be solved by model studies in the hydraulic laboratory. Fig. 4 illustrates the cofferdam resulting from these studies and used at the site.

The first phase of diversion comprised the construction of two rock fills across the river at the location of each cofferdam, thereby diverting a large proportion of the flow through the diversion tunnel and at the same time reducing the velocity in the water contained between the two rock fills. This space was then filled with selected earth materials finally closing off all river flow. The upstream cofferdam was then trimmed to shape and capped with a combination of heavy riprap, masonry and concrete.

The downstream cofferdam to some extent protects the upstream one by backwater effects. It was, therefore, felt that extra precautions should be taken in addition to the masonry and concrete capping. To this end, two lines of sheet piling were driven to prevent erosion at the top and scour at the toe.

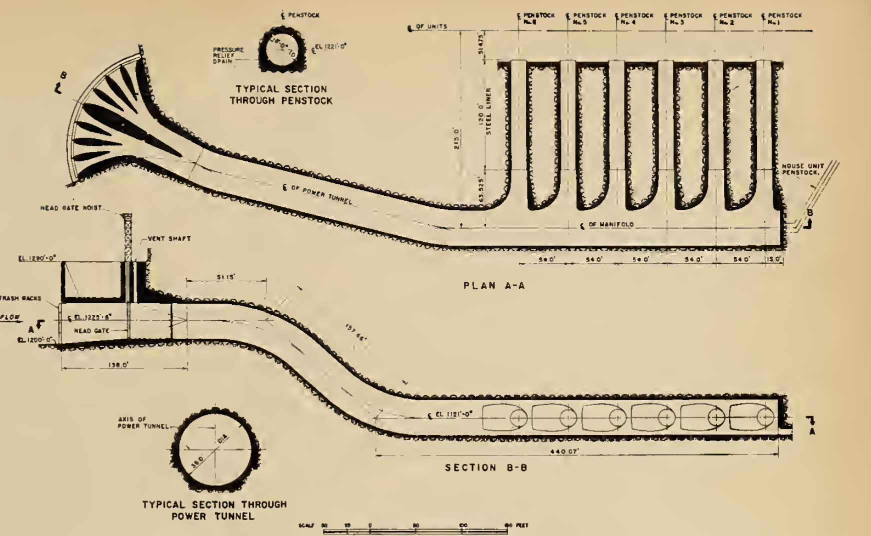


Fig. 8. Intake, Power Tunnel and Penstocks

Once the lowest blocks of the dam had been built to elevation 1130 and the stilling basin was complete, the cofferdams could be abandoned except that the downstream one will be useful until the tailrace plug is excavated. After this the lower cofferdam must be completely removed.

The Main Dam

As a result of the preliminary studies, the dam finally selected for the Warsak project is a straight gravity type concrete dam. The central, or river section, has an overall spillway controlled by nine 40 ft. radial gates.

The deck of the dam is at elevation 1290, or 5 ft. above the forebay level for the maximum design flood of 540,000 c.f.s. The normal regulated headpond level is at elevation 1269. The maximum height of the dam is 250 ft. The general arrangement and typical cross sections through the dam are shown on Fig. 5.

Immediately downstream from the toe of the spillway a stilling basin has been constructed to dissipate the energy contained in the water passed over the dam at flood time. This stilling basin was the subject of extensive model tests in the hydraulic laboratory to determine effectiveness, shape dimensions, elevations, and downstream scour. The model was tested for all flows up to the maximum design flood of 540,000 c.f.s., and operated in a satisfactory manner under conditions of uniform entry flow.

At the main dam flood waters passed over the cofferdams and through a temporary gap in the dam.

Conditions of Loading for Dam Design: (1)—Water Levels—The regulated headwater will be held at elevation 1269 feet with the tailwater at elevation 1128 feet.

In times of maximum flood the headwater level is taken as elevation 1285 ft. and the tailwater at elevation 1167 ft. For the spillway section under these conditions the hydraulic jump reduces the tailwater elevation to 1128 ft. The reservoir empty condition is also considered.

(2)—Uplift—This is included in all stability calculations, and stresses are considered with and without uplift. It is assumed to act over two-thirds of the area of the section and to vary linearly between the full headwater pressure at the heel and the full tailwater pressure at the toe.

This assumption should be conservative, as the dam as designed will have an extensive grout curtain below the inspection gallery. This grout curtain will extend approximately 0.75 times the head below the dam. Immediately downstream from the curtain a system of drain and observation holes will be drilled into the rock.

(3)—Silt—Silt or sediment carried by the flood water will be deposited in the reservoir and is assumed to build up to elevation 1230 ft.

(4)—Earthquake—As the Warsak project is located in an area with a history of fairly heavy earthquake shocks, a conservative assumption is justified in regard to the acceleration factor. In this case, for the inertia of the structure, the ratio of earthquake acceleration to acceleration due to gravity is taken as 0.15. This force is taken to act at 0.4y from the bottom of the section.

The table in Fig. 6. illustrates a typical tabulation of results for one section and one case of loading. Fig. 7. illustrates the plotting of principal stresses, together with contours of equal stress.

Consideration of Results: Stability—

The lowest value of the factor of safety against overturning is 1.41, and this occurs in the spillway section. This is due to a condition which includes all known forces, some of a transitory nature, so that the dam is considered safe against this form of failure.

The lowest value of the factor of safety against sliding also occurs under this same loading condition and is 5.

Stresses due to Differential Deflection—The steep banks of this dam give differences in the depths at each end of a 40 ft. block of the bulkhead section in the order of 35 ft. This results in a difference in the deflections at the ends of the block giving stresses due to the twisting action induced.

These stresses were investigated and the maximum found to be 63 p.s.i. in shear.

Dam Equipment — Discharge through the dam is controlled by a set of nine taintor gates, supplied by Canadian Vickers Limited, of Montreal. The gates consist of a skin plate, curved to a 48 ft. radius, reinforced by horizontal and vertical ribs supported on three main horizontal girders. These girders are, in turn, supported at their outer quarter points by two radial arms. The downstream ends of the radial arms terminate in heavy adjustable trunnions. The trunnion loads are carried back into the piers by a system of anchor bars welded at their upstream ends to the structural framework of the emergency stop-log embedded parts.

Curved roller paths, music note seals, side guide rollers, etc. are provided. Each gate is provided with an individual hoist located on a bridge structure at the level of the dam deck.

In addition to the taintor gates, one complete set of steel emergency stop-logs has been provided. These will allow any taintor gate on the dam to be unwatered for inspection, maintenance or repair. The stop-logs will be handled by mobile equipment operating on the dam deck.

Intake, Tunnel and Penstocks

The power facilities for the Warsak project, consisting of intake, power tunnel, penstocks, powerhouse, and tailrace, are all located on the south bank of the Kabul River. They are adjacent to, but independent of, the main dam structure. Their arrangement and typical sections are shown on Figs. 3, 8, and 9.

Intake and Tunnel: The reinforced concrete intake to the power tunnel is a fan-shaped structure, with its floor at elevation 1200. It is designed to draw water from the reservoir with minimum hydraulic losses. (See Fig. 8.)

The structure consists of nine converging piers supporting trash racks. Six of the piers are gradually eliminated by convergence. The two steel head gates, each 39 ft. high by 17 ft. wide, are operated by individual motors located on top of a steel superstructure. As butterfly valves have been located at each turbine scroll inlet, it was not considered necessary to supply an emergency release button for the head gates in the powerhouse control room.

The steel trash racks, placed in fabricated steel guides, are located at the intake pier noses. They have been designed to allow their upstream surfaces to be completely sheeted. The cost of strengthening the rack bar supports to this extent is but a very small fraction of the costs that would be incurred in constructing a 70 ft. high cofferdam in the intake approach to accomplish the same unwatering.

The main power tunnel in the south river bank is circular in section and 39 ft. diam. inside the concrete lining. There are two vertical and one horizontal bends which align the tunnel parallel to the powerhouse substructure. The lower section is designed as a manifold with 6 penstocks leading to the turbine scroll cases.

Careful studies and model tests were conducted to obtain the best possible shape of the junction between the power tunnel and penstocks.

Penstocks: The water is led from the power tunnel through a concrete transition section to the steel penstocks. These steel penstocks, each 18 ft. diam. by 120 ft. long, are concreted into individual tunnels in rock.

The steel shell thickness varies from ⅝ in. at the inner end to 15/16 in. at the point of connection to the butterfly valve. The design assumed that at the inner end half of the liner the load is transferred to the rock, there then being a straight line variation until the steel shell carries all the load at a point 30 ft. in from the face of the excavated rock cliff.

The plates and cans were assembled in a yard near the colony and welded by Pakistani welders trained on the spot. All the work was carefully inspected using an isotope source. The welded cans were then assembled in the tunnels and four 4 in. diam. drain pipes were erected parallel to the penstock and spaced around the circumference.

Upon completion of the penstock grouting program holes were drilled from the penstocks through the concrete between the shell and drains and on into the drains, the penstock openings then being closed with steel plugs.

The outer ends of the penstocks are controlled and closed by butterfly valves 18 ft. diam. Perhaps the only unusual feature of these rather large valves is that they are operated by vertical spindles. This design was selected to minimize excavation and concrete by placing the valves as close to the turbines as possible and still keep turbulence and hydraulic losses to a minimum.

The Powerhouse

Generating Building: Studies indicated that at this site several millions of dollars could be saved by constructing an external powerhouse on the south bank of the river rather than an underground powerhouse which had been originally contemplated, principally for reasons of security. The external arrangement which was ultimately adopted is shown on Fig. 9.

The powerhouse is of conventional design except for some special features necessitated by location or the cost of shipping materials all the way from Canada. A few of the special features are listed as follows:

(a) The draft tubes are at 60° to the powerhouse centreline instead of the usual 90°. This alignment was adopted due to the limited space available for the tailrace.

(b) The generator floor, located at the top of the generator stator, is 18 ft. below the landing area and access road, and about 15 ft. below the river level at the maximum design flood of 540,000 c.f.s. This floor is about the level of the estimated maximum flood of record, some 225,000 c.f.s.

(c) The superstructure columns are of reinforced concrete up to the top of the crane rail, and the crane rails were precast and lifted into place.

(d) The superstructure above the crane rail is of steel rigid-frame design, with a concrete roof slab.

(e) The concrete roof is of the double slab type with an intermediate waterproof membrane. It is designed to carry the switching station and concentrated truck loads, and in addition to carry a uniform triangular rock load resulting from a theoretical rock slide from a side gully or nullah.

(f) Perhaps the most unusual feature of the powerhouse superstructure is a system of anchored buttresses along the upstream wall. Up to the level of the generator floor at elevation 1149 this south wall is concreted in contact with the rock excavation. Above this level it is free standing. Some apprehension was expressed that a progressive spalling of rock might release large pieces to bear against the upstream side of the south wall. As insurance against this condition, and to place the rock in compression, a series of 5-foot thick buttresses were constructed between the wall and rock. These were spaced at 18 ft. centres, and through each prestressed anchors were located 120 feet into the rock. These anchors were stressed for a 50-ton load with a yield point at 80 tons. In the event, this anchor system was extended to include the west end wall of the powerhouse. The buttresses also served to support a cable and ventilation gallery, and the deck between the rock and powerhouse wall forms a part of the switching station approach area.

The access road from the Vale of Peshawar and the housing colony follows the south shore of the Kabul

River to an area which gives access to the tailrace deck, the powerhouse main door, the control section, and a branch leads to the switching station. The transformers can be moved along the tailrace deck and into the powerhouse for repair.

The general appearance and layout of the powerhouse interior is clearly shown by Fig. 11.

Erection Bays: The eastern 75 ft. of the powerhouse proper is an erection bay or landing area, at elevation 1167. Here equipment and materials are unloaded from trucks and trailers. Subassemblies can be put together prior to being moved into position in the turbo-generator pit. Shaft hatches and transformer detanking hatches have been provided.

There are four floors in the reinforced concrete substructure below the erection bay:

(1) At elevation 1149 the service area comprising machine shop, repair area, battery room and service water filtration.

(2) At elevation 1132, areas for building service equipment, and the oil room.

(3) At elevation 1111, the area for the two house units.

(4) At elevation 1098, a small area for the valves controlling flow to the house units and for unwatering the power tunnel.

Control Building

The control building is located at, and attached to, the east end of the powerhouse.

The lower floor at elevation 1167 contains the main entrance and reception area. The cable terminal room and operators' locker rooms are located in behind with convenient access to the powerhouse. The floor above, at elevation 1182 ft. 5½ in., contains the control room, operators' offices, and a visitors' inspection room, from which the control panels can be seen on the one side, and which looks out over the powerhouse interior on the other side.

The third floor at elevation 1202 ft. 2½ in. has a large isolated room for the control building air-conditioning equipment. In addition there are four general offices for clerical and administrative forces.

The fourth, or top floor, at elevation 1214 ft. 2½ in., is somewhat unusual for a powerhouse. The front part consists of a large visitors' lounge for government officials. This room has been symbolically finished in woods originating in Canada and Pakistan, and has a large picture window overlooking the dam, reservoir, and the Khyber hills. Behind the visitors' lounge there is a small apartment with two bedrooms, living room and kitchen. This apartment is for the convenience and use of senior government officials when visiting or inspecting the project.

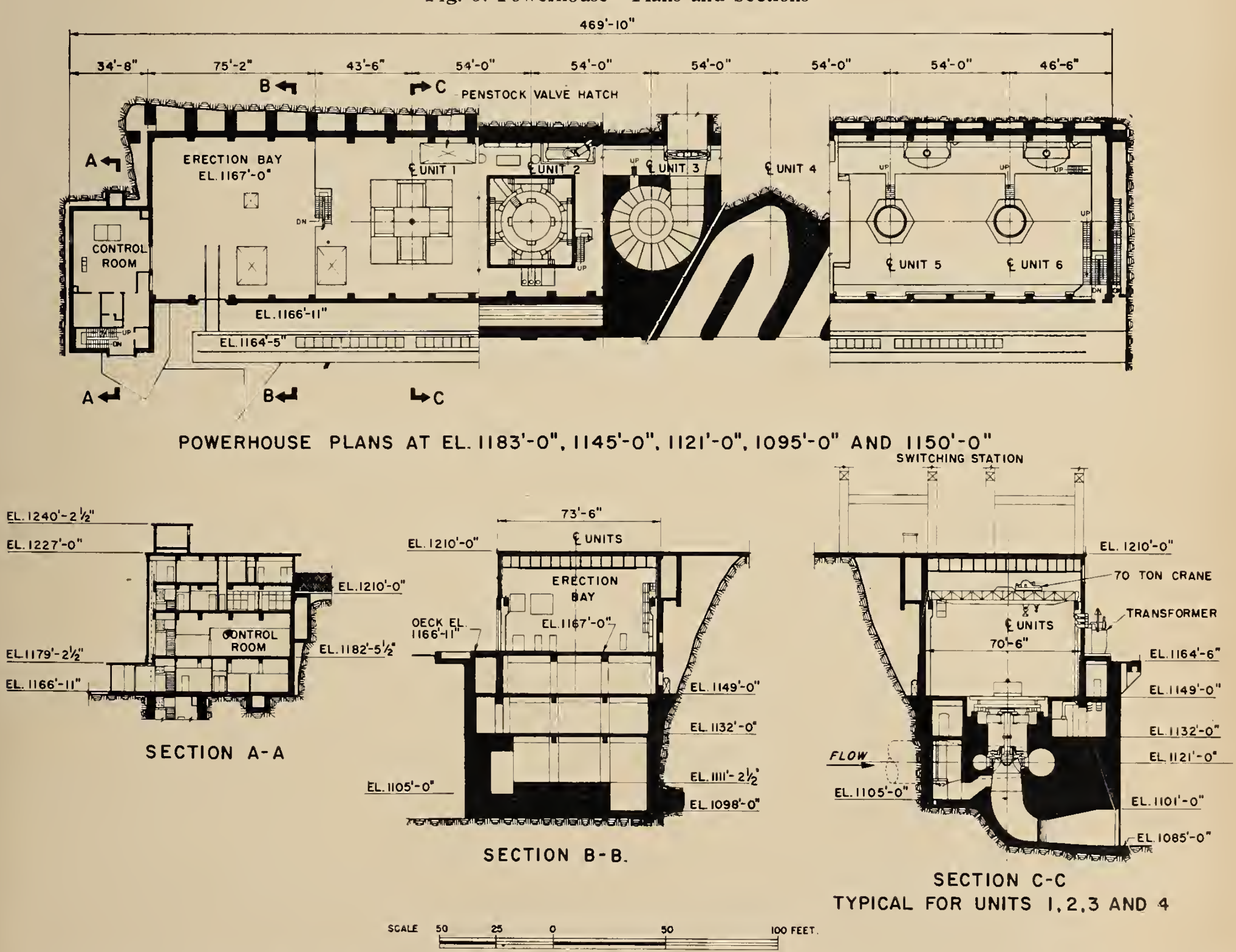
On the roof above the passenger elevator hoist and control gear are housed in a penthouse. All floors are accessible by stairs or elevator, and all are supplied with the usual facilities such as washrooms, lighting, terrazzo floor, air conditioning, etc.

Irrigation Tunnel

The Warsak project can well be described as a multipurpose one in that irrigation is an important, though secondary, feature. Two irrigation systems are contemplated, a major effort to the south and a much smaller layout on the north bank.

South Bank Irrigation Tunnel: At the time that Warsak was approved

Fig. 9. Powerhouse—Plans and Sections



for Colombo Plan participation, only irrigation to the south was contemplated. The diversion of irrigation water, 505 c.f.s. in summer and 350 c.f.s. in winter, was to be accomplished by a 9 ft. diam. lined tunnel about 3½ miles long. The tunnel outlet was to be at as high an elevation as practicable, to command as much as possible of the area between Peshawar, Jamrud Fort and Dera Kohat.

The area to be irrigated belongs to the Mullagori, Afridi and Mohmand hill tubes, and the irrigation end of the project will allow the settlement of these tribes on useful productive small farms. This additional acreage will also make the area of the former North-West Frontier Province almost self-supporting in regard to food.

Studies were made of several tunnel alignments, bearing in mind geology and costs. The layout selected has the intake structure located a few hundred feet to the west of the main power tunnel intake. The tunnel as finally constructed is 10 ft. diam. inside the concrete lining, has only one bend, is 17,100 ft. long, and has its outlet about four miles from the Warsak Colony in a southerly direction.

The intake is provided with coarse racks and is controlled by a steel headgate adapted from one of the closure gates of the temporary diversion tunnel. The air vent normally located just downstream from the headgate has in this instance been enlarged so that a jeep could be lowered into the tunnel for inspection and maintenance purposes.

The outlet end will be equipped with a regulating gate, also adapted from a previously used closure gate. A stilling basin will be constructed so as to allow low-velocity flow into the irrigation canals being excavated by the Pakistan Irrigation Branch forces.

North Bank Irrigation Tunnel: About two years after the job was under way, the appropriate Pakistani authorities decided that some irrigation facilities should be provided on the north bank.

Slots for a small slide gate and for racks were provided by an extension of block 13. A 3 ft. diam. steel pipe was embedded in the dam with the invert at elevation 1250. Beyond this point a 5 ft. diam. tunnel has been excavated for approximately a mile through the hills. This work is being done by the Irrigation Department.

Permanent Equipment

Under the terms of the intergovernmental agreement, the Canadian Government undertook to supply:

(a) "Electrical generating and related equipment (including dam gates and quantities of reinforcing steel) in amounts to be indicated to the Government of Pakistan as funds become available and, in addition, equipment and materials which cannot be made available by the Government of Pakistan."

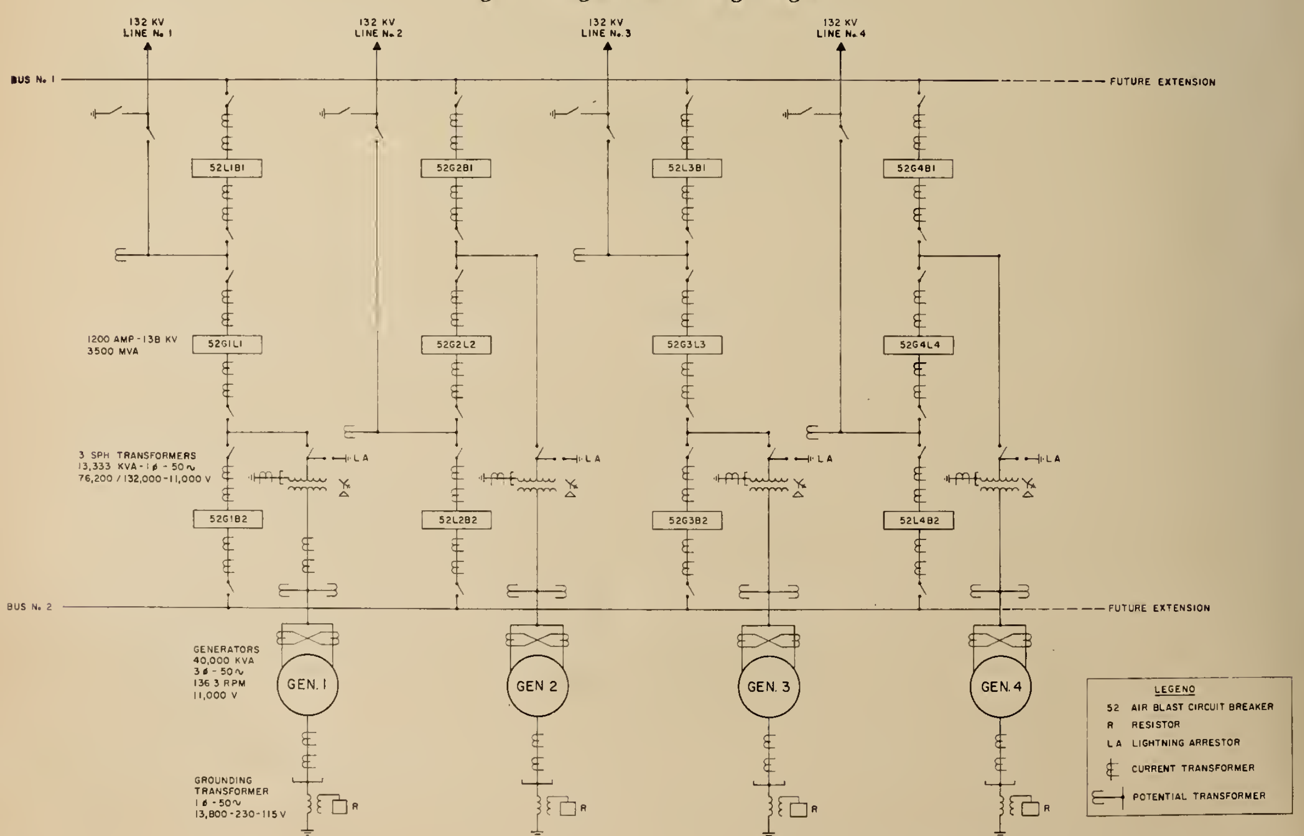
(b) "Construction plant to supplement construction equipment that may be made available by the Government of Pakistan . . ."

In the event, in order not to upset the Pakistan home markets and to speed the project, Canada supplied permanent equipment and materials except cement, and construction equipment and materials except the construction power generating units.

The turbines for this project are rated at 55,000 hp. at a head of 144 ft. and a speed of 136.3 r.p.m. To save time and to take maximum advantage of Pakistani welders trained on site, the scroll cases were preassembled in a special yard and lifted into place in large sections with only a few circumferential welds to be done in place. This procedure also allowed radiographic inspections to be made without interference with other construction operations.

The four vertical generators are type ATI-W-44 poles and are rated at 40,000 kva., 1.0 power factor, 136.3 r.p.m., 11,000 v., 3 phase, 50 cycles. The generator has been designed so that the rotor spider, shaft, and bearing bracket may be removed, leaving the rotor stacking and pole pieces in the pit. This in turn would allow dismantling and removing turbine parts and runner with a mini-

Fig. 10. Single Line Wiring Diagram



mum of disturbance. An extra bonus is achieved in that in this case the powerhouse crane capacity can be greatly decreased, the limiting tonnage to be lifted being governed by a butterfly disc and two quarter sections of body rather than a complete generator rotor. By this means the crane capacity was lowered to 70 tons.

The transformers are rated 13,333 kva., 55°C rise, type ONW, single phase, 50 cycle, 11,000 v. Delta—76,200/132,000 Y v. They are located along the tailraee deck on special pads. Single-phase transformers were specified rather than three-phase because of shipping difficulties arising due to weight and physical size.

The air blast circuit breakers are rated 138,000 v., 1200 amp., 3500 mva, 3 tank, 3 pole, and are located on the roof of the powerhouse together with the associated motor-operated disconnects, and switching station steel structure.

The main control switchboard is a combined benchboard and tunnel type duplex structure for control metering and relaying of both the main generating units, house service units and high voltage breakers. A separate cubicle for indicating alarm and various operating conditions is also located in the control room.

A station service switchboard containing the house unit circuit breaker equipment and station service distribution feeders is located in the erection bay area of the powerhouse.

The facilities provided in the control room allow the station operator to select either automatic or manual control of both the main and house service generating units. The automatic control provides for starting any unit by the operation of one control switch after the penstock valve has been opened. The unit selected will then be brought to synchronous speed and connected to the system. Automatic shutdown will disconnect the unit from the system and close the penstock valve once the turbine wicket gates are closed. Load control of all the units is done by the operator. Manual operation from the control room allows the operator to initiate each step in the startup or shutdown.

Protection of the equipment is designed to allow each main generator and transformer to operate as a unit. The protection of the 138 kv. lines leaving the switching station is a separate entity from this project.

Fig. 10, single line wire diagram, outlines the electrical system.

The nine taintor sluice gates were each 40 ft. high by 40 ft. wide clear opening. The maximum lift of the gate lip is 50 ft. The set of nine gates can discharge approximately 320,000 c.f.s. at normal headpond level. The spillway, however, is designed for a maximum flood of 540,000 c.f.s. with surcharge on the reservoir levels.

The taintor gates will be operated from a console in a control house at the south end of the dam. A timer on the console will operate the gates in a fixed sequence. First the centre gate will rise 1 ft., then the next two, and so on until all gates are up 1 ft. At that time the centre gate will rise a second foot and the whole sequence will be repeated in steps until all gates are fully open. This perhaps elaborate procedure was considered advisable because of the high discharge per foot width of spillway, to operate the stilling basin at maximum efficiency, to minimize downstream erosion, and maintain optimum tailrace conditions.

Most of the rest of the permanent equipment is fairly standard. All items were inspected on behalf of the Canadian Commercial Corporation by the Department of National Defence Inspection services prior to shipment from Canada.

Construction

A Canadian general contractor, Angus Robertson Limited of Montreal, was retained in the summer of 1955, and did an impressive job of quickly assembling several shiploads of construction equipment and preventing delay. He supplied a contractor's complete supervisory staff, plus many categories of skilled workers. It must be remembered at all times that the Warsak project was in an undeveloped tribal area and that all special skills had to be trained. The contractor's problems were covered in a companion paper prepared by Mr. C. G. Kingsmill.

Organization and Acknowledgments

To one accustomed to consulting assignments from private owners or power commissions, the organizational requirements of doing similar work under the Colombo Plan may seem unduly cumbersome. Two factors must, however, be continually kept in mind. In the first place, any Colombo Plan project involves two separate governments and, in the second place, most government operations are necessarily more complex due to their very nature and to the many departments, divisions, or agencies involved.

The complexity unquestionably increases the time and paper work and naturally increases the total cost.

At the site, where the work was actually carried on, there were three groups represented by staff on the job: the consultants, the contractors, and the Pakistanis (Warsak Dam Project Organization). The pace of work was probably faster than would normally prevail in such a tropical climate, but considerably slower than that of similar work in Canada.

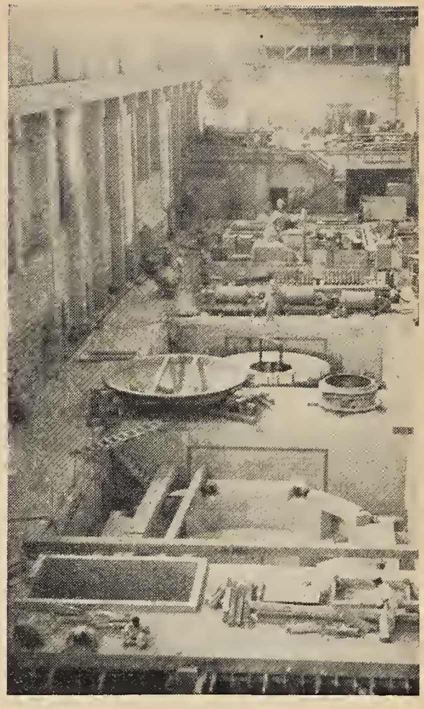


Fig. 11. Interior of the Warsak Station. Erection area at far end.

We had to deal with six Canadian and eight Pakistani government bodies or agencies. Even though at times there may have seemed to be too many cooks, an overall desire prevailed to do a good job with utmost cooperation.

For a project such as Warsak it is impossible to acknowledge the assistance given by all who contributed to its planning, organization, design, supervision, and construction. The author of this paper would like to thank all who contributed to Warsak, whether their names appear below or not.

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R. G. Johnson, President
S. Ross, Project Engineer, Foreign Projects Division
Canadian Commercial Corporation
C. J. K. Smith, Projects Officer
H. G. Acres & Company Limited
E. L. Miller, Project Manager
R. L. Clinch, Senior Project Engineer
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C. G. Kingsmill, Assistant to the President
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Warsak Dam Project Organization
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A. R. Quereshi, now Chief Engineer
Shah Nawaz Khan, Superintending Engineer (Field)

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G. O'Blenes
Wiggins-Teape, England

A. B. Truman
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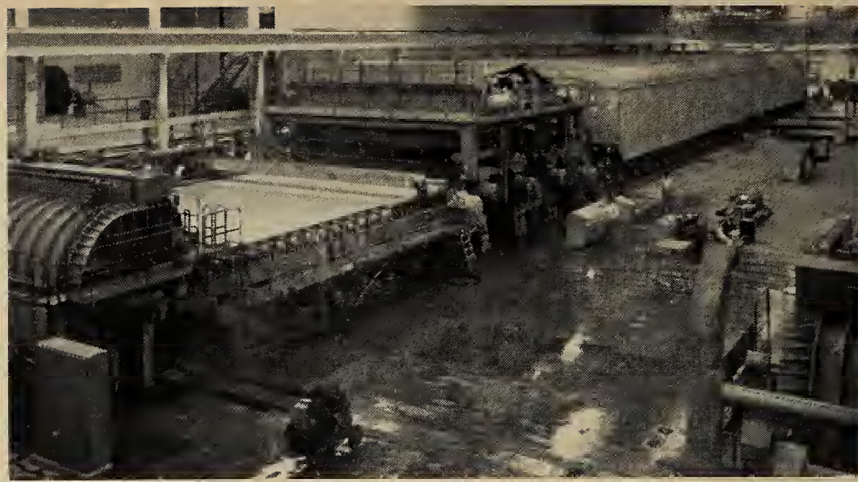


THE DRAINAGE PROBLEM ON A NEWSPRINT MACHINE

A description is given of the Drainage Tester developed by Anglo Paper Products Limited to investigate the drainage properties of newsprint stock under conditions closely simulating the conditions on an actual paper machine. The value of the drainage resistance coefficient is determined using average rates of flow and average values of suction. Results of other investigators using different types of testing devices are discussed, and some results obtained with an apparatus similar in principle to the Anglo Paper Products tester are compared with the results of this investigation. Finally, the experimentally-determined drainage coefficients are compared with those found on the paper machine itself.

FIG. 1 shows in line form the wet end of a typical Fourdrinier paper machine on which almost all of the drainage occurring in the table role section is due to the suction produced hydrodynamically under the wire where it passes over the supporting table rolls. The theory of this process has been the subject of several papers since 1956. These theoretical treatments have considered the process of draining water as a specialized form of filtration, and equations have been evolved relating the suction produced by a table roll to the drainage resistance of the fibre mat on the wire.

It is possible, therefore, to compare theory and practice in a number of ways, according to the known experimental data:

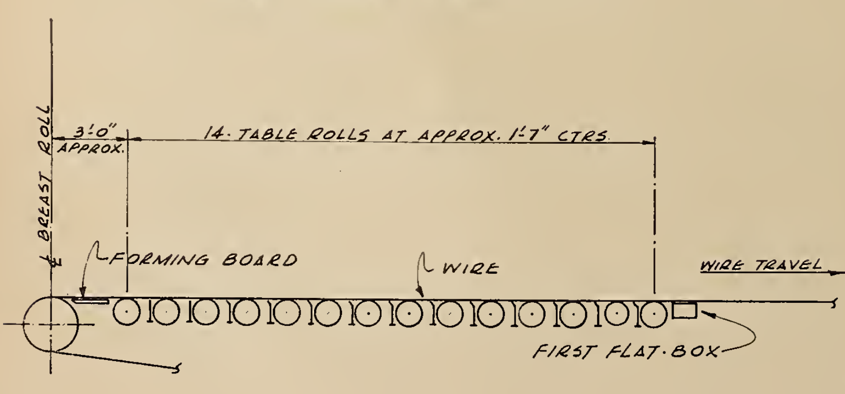
(a) if the exerted suction is directly measured, and discharge quantity from a table roll known, the distribution curve for the suction which theory predicts can be compared directly with that measured;

(b) if the quantity drained at a roll is measured and the theory assumed to be correct, drainage coefficients can be calculated and then compared, after suitable weighting, with those determined from laboratory experiments.

In practice the total drainage of the wire table is measured, and a laboratory determination of drainage resistance can be used if certain assumptions are made so that the total amount drained from all table rolls can be compared with that measured.

The results obtained can then be used to predict performance under different machine conditions; for example, changes of machine speed or stock temperature. In the present treatment only the end results of the major theories advanced are considered.[5]

Fig. 1. Typical Fourdrinier Wet End.



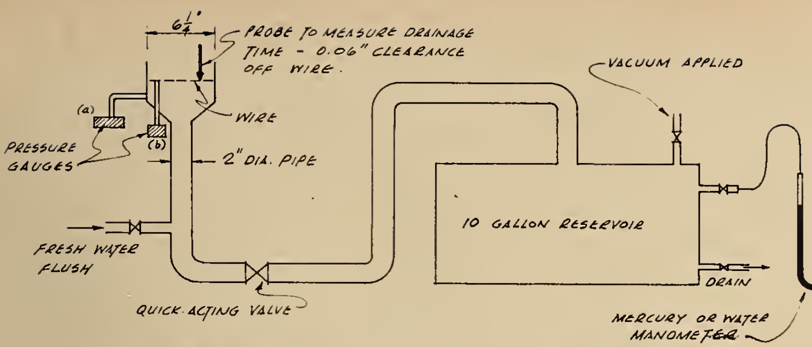


Fig. 2. Diagramatic sketch of A.P.P. drainage tester.

If the drainage resistance of the fibre mat can be accurately determined then the drainage of actual paper machines can be compared with that predicted from theoretical treatments and laboratory measurements, and ultimately, for different stocks, accurate predictions of the drainage capacities of any given paper machine will be possible.

The laboratory determinations so far described in the literature have the following weaknesses of (i) using very dilute solutions, rather than consistencies ordinarily used on the paper machine, and (ii) excessively long drainage times which are not realistic compared to operating conditions.

Because of these weaknesses no correlation between laboratory-determined drainage resistances and paper machine operation is possible. Accordingly, a new type of drainage testing machine was developed by Anglo Paper Products Limited*, which works on the principle of a suddenly-applied vacuum at the underside of a wire on which is a sample of paper stock of the consistency used on the paper machine. Fig. 2 shows a diagrammatic sketch of this drainage tester.[1] (See Appendix 1.)

It is the purpose of this paper to describe measurements made on this Sheet Machine, enabling the drainage resistances to be determined, and the results of the application of these resistances to paper machine data.

Experimental

The operation of the Sheet Machine may best be described by reference to Fig. 2.

The apparatus was designed so that a controlled suction was applied at all times; with the quick-opening valve to the vacuum chamber closed the section of piping between valve and wire is filled with water to the level of the wire. The vacuum chamber is then evacuated to the required vacuum and the pulp mixture is added to the top of the wire and agitated continuously. The agitator is then removed and simultaneously the valve to the vacuum chamber is opened. The probe of the electronic apparatus registers the liquid level throughout the draining process, thus giving a measure of the time during which drainage takes place, as well as the actual drop in level which occurs.

*J. Mardon and B. Wahlstrom.

A typical suction-time recording is shown in Fig. 3 in which the upper plot shows the drainage time (from the change in liquid level to complete drainage) and the lower plot shows the change in pressure. It may be noted that complete drainage is reached at the point where maximum suction is recorded; following this, air is pulled through the wire and the applied vacuum is gradually lost until atmospheric pressure is finally attained once more.

Drainage tests on the Sheet Machine have been photographed using a Fastax camera in order to check the electronic measurements visually[13]. For photographic study of these tests a ruler was placed upright in the stock container so that the actual depth of the stock could be seen on the film. Analysis of the film on a frame-by-frame analyser enabled one to check the time of drainage, although of course, no check could be made on the applied vacuums since the speed at which the film was exposed (1,000 frames per second, usually) was known. In the actual analysis of the films it was found that the presence of the ruler was of little help, and that more accurate readings could be made using the cross-hairs of the analyser with the ruler serving only as a means of obtaining the proper scale. Fig. 7 shows a typical plot of film results.

Analysis of the suction-time recordings may be done as follows (for simplification, newsprint stocks only are considered in this paper)[7]. It should be noted that for purposes of plotting suction versus drainage time the peak suction recorded on the trace should not be used, but rather the *average* suction value which is determined, with reference to Fig. 4, by:

$$S(\text{ave. over time } t/x) = \frac{1/2 \times (t/x) \times S_{\max}}{t/x} = \frac{S_{\max}}{2}$$

$$S(\text{ave. over time ``}t\text{''}) = \frac{1/2 \times S_{\max}(t/x) + 0(t - t/x)}{t} = 1/2 \times S_{\max}(t/x) \times 1/t = \frac{S_{\max}}{2x}$$

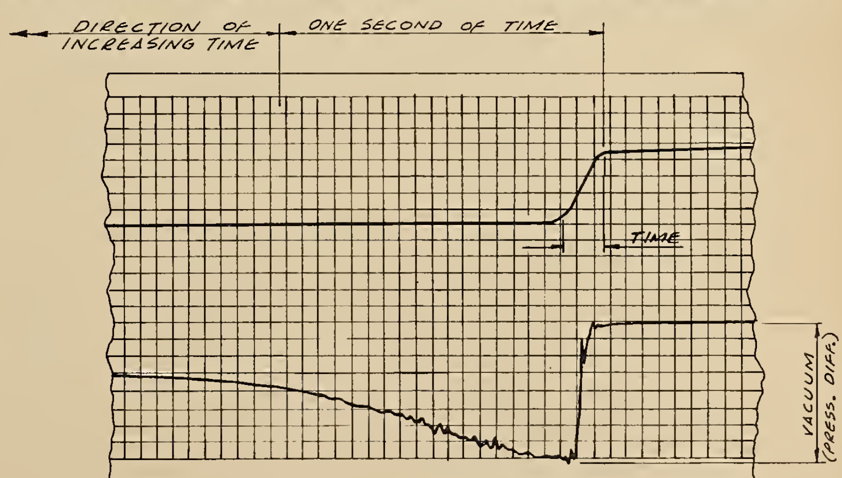
where:

x = any integer greater than one

$S_{\max}$ = peak suction recorded

The above assumes a linear drain-

Fig. 3. A typical drainage recording. (*Note*: **this is a tracing of an actual recording.**)



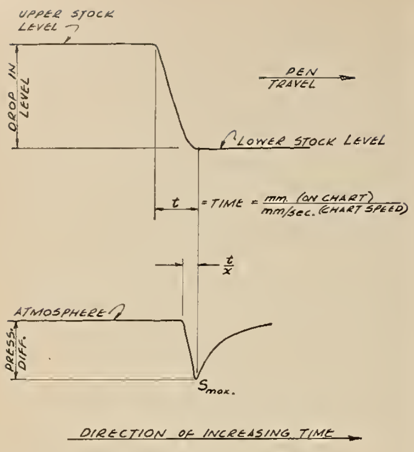


Fig. 4. Analysis of drainage recordings.

age rate curve; this assumption may be safely taken for the present discussion of tests on newsprint stock.

The laboratory determination of drainage resistance of a pulp stock is accomplished by calculating the reciprocal of the resistance, or the drainage coefficient. It has been found that depending upon whether the flow through the wire is laminar or turbulent this coefficient appears in the relationship:

$$W^{\psi} = \frac{K}{\mu} \cdot S,$$

ψ being equal to 1 and 2, respectively, for laminar and turbulent flow.

where:

W = drainage *rate*
K/μ = drainage coefficient
S = Suction

In actual fact the value of "ψ", the power to which "W" is raised, probably lies somewhere between unity and two, since the flow is neither completely laminar nor completely turbulent.

In performing the drainage tests on the A.P.P. Sheet Machine one measures the time during which drainage takes place. If, at the same time, one knows the area of the mat through which the water drains, and the total amount of water drained is collected, it is possible to calculate "W", the average drainage rate through the mat of pulp.

$$\text{e.g.}\ -W = \frac{\text{quantity of water drained}}{\text{mat area} \times \text{drainage time}}$$

$$= \text{drainage rate (average)}$$

TABLE I

Results of Application of Taylor's No-Mixing Theory To A Paper Machine (Machine Speed U = 980 cm./sec.)

Roll No.	*Radius (cm.)*	*K/μ (cm³/dyne-sec.)*	*q (cc./sec.)*	$S_{ave.}$ *(cm. H_2O)*
1	16.5	15.6×10^{-5}	111.0	212
2	16.5	14.4×10^{-5}	94.5	216
3	16.5	13.2×10^{-5}	79.6	208
4	16.5	12.0×10^{-5}	66.0	216
5	16.5	11.4×10^{-5}	59.6	212
6	16.5	10.8×10^{-5}	53.7	208
7	16.5	10.2×10^{-5}	47.7	213
8	16.5	9.6×10^{-5}	42.2	214
9	16.5	9.0×10^{-5}	37.2	218
10	16.5	8.4×10^{-5}	32.6	234
11	16.5	7.8×10^{-5}	28.0	234
12	16.5	7.2×10^{-5}	23.9	232
13	14.0	6.6×10^{-5}	16.9	246
14	16.5	6.0×10^{-5}	16.5	256
		Total =	709.4	

TABLE II

Results of Application of Taylor's Complete-Mixing Theory To A Paper Machine (Machine Speed U = 980 cm./sec.)

Roll No.	*Radius (cm.)*	*K/μ (cm³/dyne-sec.)*	*q (cc./sec.)*	$S_{ave.}$ *(cm. H_2O)*
1	16.5	15.6×10^{-5}	272.0	239
2	16.5	14.4×10^{-5}	232.0	275
3	16.5	13.2×10^{-5}	195.0	280
4	16.5	12.0×10^{-5}	162.0	308
5	16.5	11.4×10^{-5}	146.0	311
6	16.5	10.8×10^{-5}	132.0	312
7	16.5	10.2×10^{-5}	117.0	316
8	16.5	9.6×10^{-5}	103.0	328
9	16.5	9.0×10^{-5}	91.2	328
10	16.5	8.4×10^{-5}	79.9	342
11	16.5	7.8×10^{-5}	68.8	340
12	16.5	7.2×10^{-5}	58.5	328
13	14.0	6.6×10^{-5}	41.4	363
14	16.5	6.0×10^{-5}	40.4	312
		Total =	1,739.2	

Thus, having determined from laboratory results the value of "W" and simultaneously obtaining the suction exerted (by means of the electronic measuring devices) one may calculate the value of K/μ, the drain-

Fig. 5. Suction vs Drainage Time-Mixed Stock.

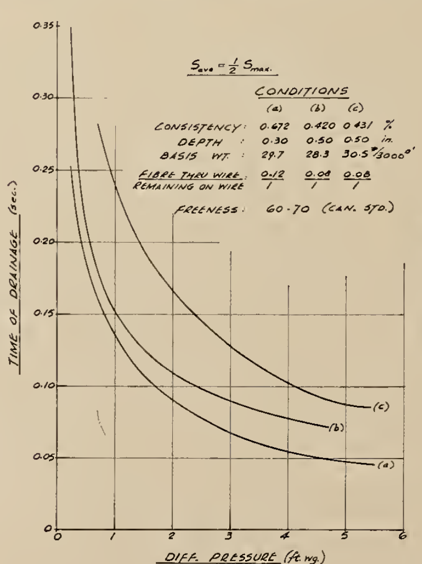
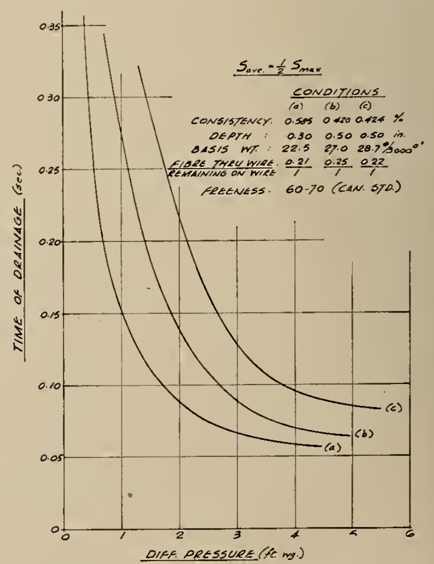


Fig. 6. Suction vs Drainage Time Headbox Stock.



age coefficient.

This has been done using both mixed (in the laboratory) and actual headbox stocks, and an average value of $K/\mu = 12 \times 10^{-5}$ cm³/dyne-sec. will be used to illustrate a comparison with the drainage on an actual paper machine.

Discussion of Results

The results of a number of tests made on the A.P.P. Sheet Machine are plotted in Fig. 5, 6, 7 and 8 [1]. Fig. 5 and 6 represent plots of average suction versus drainage time for mixed and headbox stock respectively, where the average suction has been taken as one-half the peak suction recorded on the tracing.

For the headbox stock (Fig. 6) there appears to be an exponential decrease of time with pressure in every case; that is, a rapid decrease to about 1.5 ft. wg. of suction, then a slow rate of decrease of drainage time to about 3.5 ft. wg. and then very little change in time for further suction increase. The corresponding curves for mixed stock (Fig. 5) are more uniform in slope and do not exhibit such a markedly exponential change in drainage time. The exponential nature of the curves for both cases, however, is borne out by straight-line plots using logarithmic axes.

On each figure the ratio of stock going through the wire to that remaining on top is noted. For headbox stock, Fig. 6, this varies from 0.21/1 to 0.29/1, and for mixed stock, Fig. 5, it is much less, being between 0.08/1 and 0.17/1. Comparable figures obtained for an operational newsprint machine were between 0.41/1 and 0.51/1, which might indicate that the A.P.P. Sheet Machine is directly comparable with the wire part of a paper machine at the suction boxes, rather than at the first few table rolls. However, some discrepancy is definitely due to the upthrust of water through the wire on the upstream side of a table roll on the machine which disturbs the fibre mat already formed and so allows more fibre to drain through with the water.

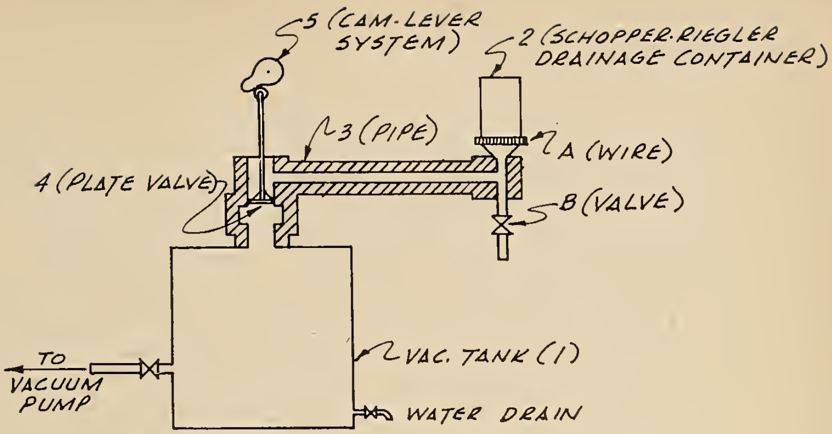


Fig. 8. Apparatus used by Müller Rid & G. Pausch.

Method: Drainage container (2) placed on wire (A) with valve (B) open and drainage occurs by gravity until no water drains off. Valve (B) then closed and valve (4) opened by cam (5), thus putting vacuum on bottom of sheet. By rapid valve opening some air enters tank (1), raising tank pressure, and thus quantity of air through sheet can be measured. By weighing sheet after removal from wire and find bone-dry weight percentage of water is found.

Regarding the time element, drainage times appear to be shorter for mixed stock than for headbox stock. This is due to the number of fines present in the latter which are absent in mixed stock.

Total times of drainage vary within the range of 0.15 to 0.30 seconds.

Comparison with Existing Literature

Part A: Numerous investigators have employed various types of apparatus to study aspects of the drainage problem. Bergstrom and Knell[8] used water only to determine the pressure drop across the wire by placing the wire at right-angles to the flow in a pipe, thus allowing continuous flow which is not possible on the A.P.P. machine, although the latter is superior when using stock.

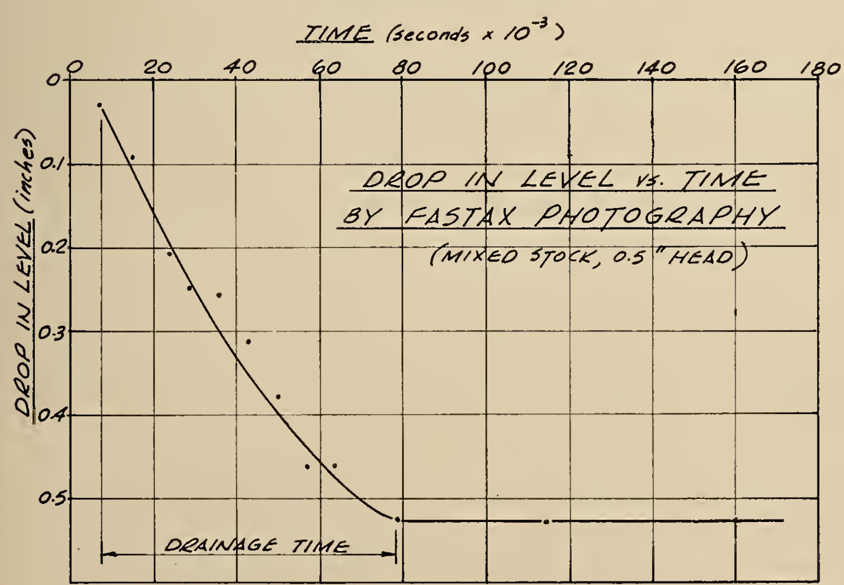
Corte[9] used apparatus similar to a Williams freeness tester to determine the relationship between stock quality, concentration, temperature and drainage time, but his times were very long and he used dilute suspensions draining by gravity alone.

Brecht and Rosenlaw[10] used an apparatus similar to that of Corte, but did not use stock in their measurements. Hanatchek[6] continued along the same lines, also using water.

Ingmansen, Whitney and Han,[11] and Hendry and Maynard[12] studied drainage resistances of pulp, but their apparatus entailed a long, slow period of drainage.

There is one set of results which will be compared with the A.P.P. curves. Muller Rid and G. Pausch[4] using the apparatus shown in Fig. 8 conducted drainage tests on various stocks. Their apparatus was similar in principle, if not in action, to the A.P.P. machine. These results are plotted in Fig. 9 along with the duplicated curves of Fig. 5 and 6, and appear to roughly parallel the bottom portion of the A.P.P. curves.

Fig. 7. Drop in level vs time by Fastax photography.



The total suction times are of the order of 0.20 seconds as compared with 0.30 seconds on the A.P.P machine, while vacuums are much larger than for the latter results.

Actually, these Rid-Pausch curves do not compare well with the A.P.P. results in view of the fact that the former investigators allowed drainage to proceed by gravity before applying any vacuum, and used much freer stocks than the A.P.P. newsprint stock. Although a considerable amount of drainage takes place under vacuum, the vacuum applied is extremely high (about four times that exerted by the A.P.P. machine) and so the two sets of results are not strictly comparable. Like the tests of other investigators mentioned above the method of Rid and Pausch does not approximate closely drainage on an actual paper machine, but is akin to the operation of the flat-box section. However, since the apparatus used resembles the Anglo Paper Products machine the above remarks are included.

Part B: If, for any paper machine, a material balance is available which gives the total drainage on the table roll section, then provided the average drainage coefficients corresponding to those on the wire can be obtained from laboratory measurements, a comparison of the predictions from theory of the total table roll section drainage can be made with this material balance.

Knowing this, certain forecasts can be made regarding changes in machine speed, stock temperature, etc.

This treatment has been applied to a newsprint machine with 14 table

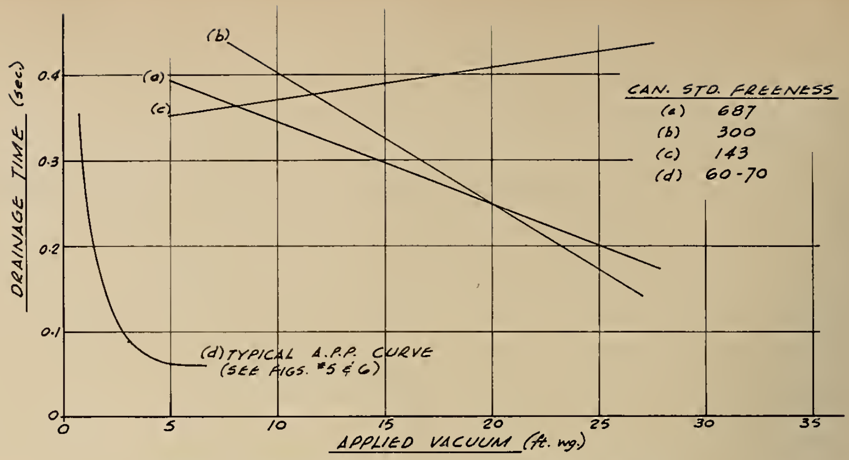


Fig. 9. Comparison of A.P.P. & Rid-Pausch results.

rolls, as listed in Tables I and II (see Fig. 1), and on which approximately 20% of the total drainage was at the breast roll and forming board.

Two theories are used as a basis of comparison for the experimental results with those found on an actual paper machine, both of which were formulated by Sir G. I. Taylor.[2, 3] The first of these assumes no mixing of the stream lines (i.e.—laminar flow) and predicts the quantity of water drained at a table roll to be:*

$$q = 0.295 R \rho^2 U^3 (K/\mu)^2 \qquad (1)$$

where:

q = c.c. per sec. per cm. of width of the wire.

R = table roll radius (cm.)

ρ = specific gravity (unity)

U = wire speed (cm./sec.)

K/μ = drainage coefficient (cm^3/dyne-sec.)

The second theory of G. I. Taylor assumes the opposite case to that of his first theory; i.e. — complete turbulent mixing throughout the depth of the fluid without any surface friction effect, or, turbulent flow with the streamlines no longer existing, and shows the quantity of drained water to be:

$$q = 0.7536 R \rho^2 U^3 (K/\mu)^2 \qquad (2)$$

where R, ρ, U, K/μ and q have the same connotation as before.

In the calculated results which follow the average drainage coefficient K/μ has been taken as 12 x 10^{-5} cm^3/dyne-sec. The simplifying assumption has been made that K/μ varies linearly down the wire table. Although this is known to be incorrect, results have shown[5] that the error involved is not likely to be great. Fig. 10 shows the K/μ distribution used in the present case.

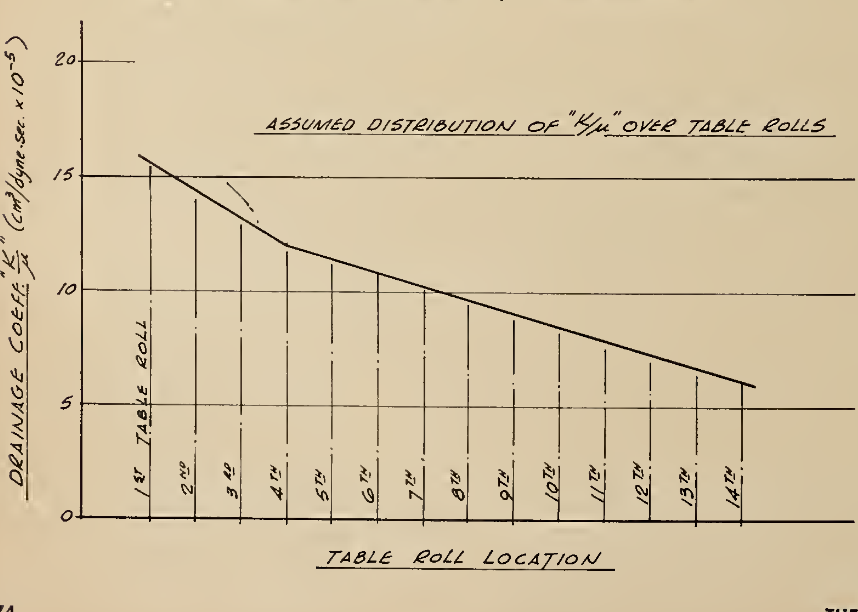
Tables I and II show the values taken for K/μ, the quantity "q" drained from each table roll as calculated by Equations 1 and 2, and the average suction value found for each roll.

For a machine speed of 980 cm./sec. Taylor's No-Mixing Theory yields a total calculated drainage quantity of 709 cc/sec. per cm. of wire width, which may be extrapolated to 405 litres/sec. for whole machine width. This compares well with a total of 376 l./sec. actually found by means of a material balance.

For the same machine conditions as above Taylor's Complete-Mixing Theory gives the results shown in Table II. The total drainage now amounts to 990 l. per sec. over the whole machine width, or about 2½ times the total found from the material balance.

From the above figures it appears

Fig. 10. Assumed distribution of "K/μ" over table rolls.



*Reference 5 gives a full derivation of Equation 1 above and also Equation 2 which follows for Taylor's second theory.

that the No-Mixing Theory gives good agreement with actual machine performance and that the Complete-Mixing Theory gives predicted drainage results that are much in excess of those actually obtained. It is believed from a more exhaustive study than can be reported here that the agreement is fortuitous and that the applicable theoretical treatment must take into account the value of ψ corresponding to that of the drainage process on the paper machine. Cavitation in the draining fluid also affects the results.

Thus, as a first approximation only, for newsprint stocks at speeds in the range of 800-900 cm./sec. the No-Mixing Theory gives predicted drainage values that approximate to those found from material balances if the values of K/μ found by the A.P.P. Sheet Machine are used in the calculations.

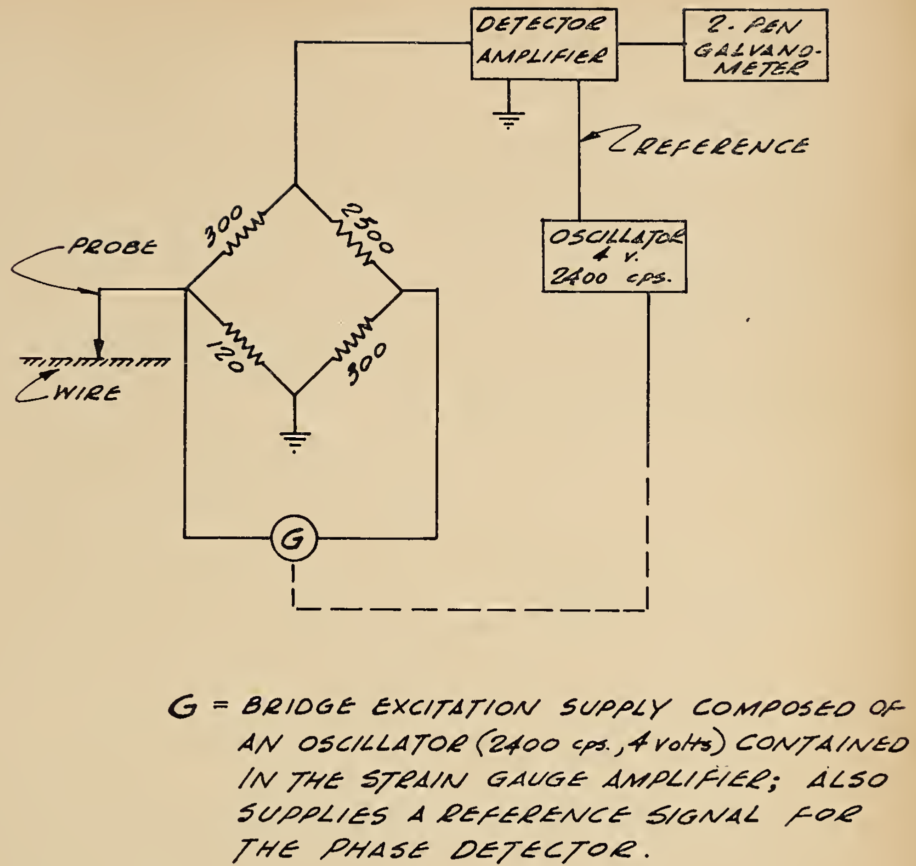


Fig. 11. Circuit diagram of A.P.P. timing device.

Conclusions

Although the foregoing remarks have touched very briefly upon paper machine drainage and laboratory investigation of the drainage problem, certain points stand out in summary.

(1) In order to properly evaluate wire table performance on full-scale paper machines, drainage coefficients must be determined in the laboratory using equipment such as the A.P.P. Drainage Tester which closely simulates actual operating conditions;

(2) Further theoretical and experimental work is needed in this field to enable the exact relationship between theory and practice to be determined.

APPENDIX I

Description of Anglo Paper Products Equipment

The apparatus as shown in Fig. 2 is self explanatory except for the part around the wire. The machine consists essentially of a removable plate and wire suitably centred on the frame. The stock container rests on the wire with an integral round rubber gasket to prevent leakage, and is tightened against the wire by means of four wing-nuts.

Agitation of the stock as required during the time interval between the stock being placed on the wire and the start of the operation is done manually using a large mesh (4 holes per in.) grid.

The pressure gauges used were as follows: (a) a 15 p.s.i. differential Northam gauge, which is a variable reluctance type with two external resistance circuits completing a Wheatstone bridge. This gauge was used in the static position shown in Fig. 2 in determining the pressure differential through the fibrous mat; (b) a 1 p.s.i. differential Statham gauge which is a strain gauge, full-bridge type. This gauge was used in the total head position as shown in Fig. 2 and also in the static position to determine the head loss through the wire of water only.

The centre-line of the static opening was 15/16 in. below the wire while the diaphragm of the Northam gauge was 3½ in. below the wire. The total head tube was placed directly against the underside of the wire.

Fig. 11 shows the circuitry involved in the electric timing device. The probe inserted in the stock had a clearance of 0.06 in. off the wire. Before contact is made by water between the probe and the wire, the electrical path between the probe and the wire, the machine body being grounded, offers infinite resistance; the bridge, therefore, can be balanced.

The resistance of this path varies inversely as the level of stock: the higher the level, the lower the resistance and hence the larger the change on the recorder.

The recording equipment used was the Sanborn 64 Series, Strain Gauge Amplifier with matching Recorder.

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DETERMINING MACHINE FOUNDATION NATURAL FREQUENCIES BY ANALYSIS

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The analytical procedures outlined in this paper are based on Rayleigh's Principle and may be used to find the natural frequencies for all six degrees of freedom of rigid foundations. Analytical determination of natural frequencies for rotational vibration about various axes is usually not practicable because of the unavailability of the values of mass moments of inertia of machines. For this reason, the application of the method to vertical and horizontal vibration, only, is given here. It is further shown that the values obtained for the vertical natural frequencies of machine foundations agree very closely to those given in the empirical plot of Tschebotarioff.

IT HAS been found[1] that the natural frequencies of most foundation soil systems are less than 30 c.p.s.; consequently there is the possibility of resonance occurring if the rotational speed of a machine mounted on a soil supported foundation is less than 1,800 r.p.m. Most stationary reciprocating machines have rotational speeds less than 1,800 r.p.m., and consideration of the dynamic characteristics of the foundation of such machines is necessary in order that resonance be avoided. Dangerous fatigue stresses and other objectionable factors, such as excessive vibration transmitted to buildings and other adjacent structures, are usually present when the foundation is at or near resonance.

Analytical methods, along with the qualitative consideration of certain factors not amenable to analysis, can provide a basis for at least an approximate determination of the natural frequencies of the various modes of vibration. However, determination of amplitudes of vibration of foundations is highly uncertain by analytical methods.

A rigid foundation is a system with six possible degrees of freedom. If a foundation cannot be considered rigid, then more degrees of freedom are introduced. Each degree of freedom has a natural frequency associated with it, and it is desirable that the rotational speed or twice the rotational speed of the machine should not be within 20% of any one of these natural frequencies. The term "natural frequency" is used with some misgiving, as a soil-foundation system displays non-linear characteristics, and any natural frequency of the system is not a constant but a function of the disturbing force[2]. This indicates that linear theories are not strictly applicable to analysis of the dynamic behaviour of soil systems; however, linear theories can be used if the magnitude of the disturbing force is small compared with the weight of the machine and foundation.

Satisfactory foundations for low speed machines usually have natural frequencies which are higher than the rotational speed of the machine[3]. Foundations for high speed machines, such as gas and steam turbines with rotational speeds greater than 3,000 r.p.m. have natural frequencies below the rotational speed of the machine. The two types of machine, therefore, give rise to rather different foundation design problems.

A Theoretical Analysis of Soil Vibrations

(*a*) *Simple Spring Supported Mass Analogy;* Several procedures have been suggested to determine foundation natural frequencies[3]. Perhaps the most obvious procedure is to consider the foundation as a single degree of freedom spring supported mass, with the soil being assumed a massless spring. The natural frequency is then given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{Kg}{W_v}} \qquad (1.1)$$

where

W_v = weight of foundation and machine

K = spring constant (restoring force per unit displacement)

g = acceleration of gravity

This procedure is an oversimplification and Equation 1.1 gives unsatisfactory results. One refinement consists of making an allowance for the soil which vibrates in phase with the foundation by considering this soil dynamically equivalent to a mass of weight W_s, vibrating with the same amplitude as the foundation.
The natural frequency is then given by:

$$f = \frac{1}{2\pi}\sqrt{\frac{k'Ag}{W_s + W_v}} \qquad (1.2)$$

where

k' = coefficient of dynamic subgrade reaction (restoring force per unit area for unit displacement)

A = area of foundation bearing on soil

$k'A$ = stiffness (restoring force per unit displacement)

W_v = weight of foundation and machine.

The determination of f is dependent on the values of k' and W_s.

The value of W_s can only be obtained from the results of experiments. It has been found[1] that W_s is usually the dominant weight in Equation 1.2.

Lorenz[2] assumed k' was constant for a given soil, however, Tschebotarioff and Ward[4] have shown that this is incorrect.

Apart from the indeterminate nature of W_s and k', Equation 1.2 has the disadvantage that it gives the natural frequency for only the vertical degree of freedom, and often other degrees of freedom may have to be considered.

(*b*) *Bearing Pressure;* The average bearing pressure, W_v/A, must be given careful consideration by the designer of foundations for low speed machines.

It has been found[3] that the lower the bearing pressure, the higher is the natural frequency of the foundation on a given soil. This indicates that if the area of a foundation is increased and thus the bearing pressure reduced, the stiffness ($k'A$) will be increased more than the total vibrating weight ($W_s + W_v$). The static modulus of subgrade reaction is increased when the bearing pressure is reduced. It is therefore reasonable to assume that the dynamic modulus will likewise be increased when the bearing pressure is reduced.

(*c*) *Analogous Damped, Spring Supported Mass with Disturbing Force;* When the periodic force is vertical sinusoidal, and acts such that the foundation undergoes only vertical displacement, then the amplitude frequency characteristics of the foundation are similar to those of a damped, single degree of freedom, spring supported mass[3]. Soil vibrators used for experimental work are an example of this[5]. Most machine foundations have more complicated amplitude-frequency relations due to the several degrees of freedom and also the higher harmonics of the periodic disturbing forces. However, some investigators have studied foundations with amplitude-frequency characteristics similar to those of a single degree of freedom, damped, spring supported mass. This suggests that the concept of a spring supported mass with viscous damping is useful for qualitive consideration of the dynamic behaviour of machine foundations. For example, the effect of adding mass to a foundation may be studied qualitatively.

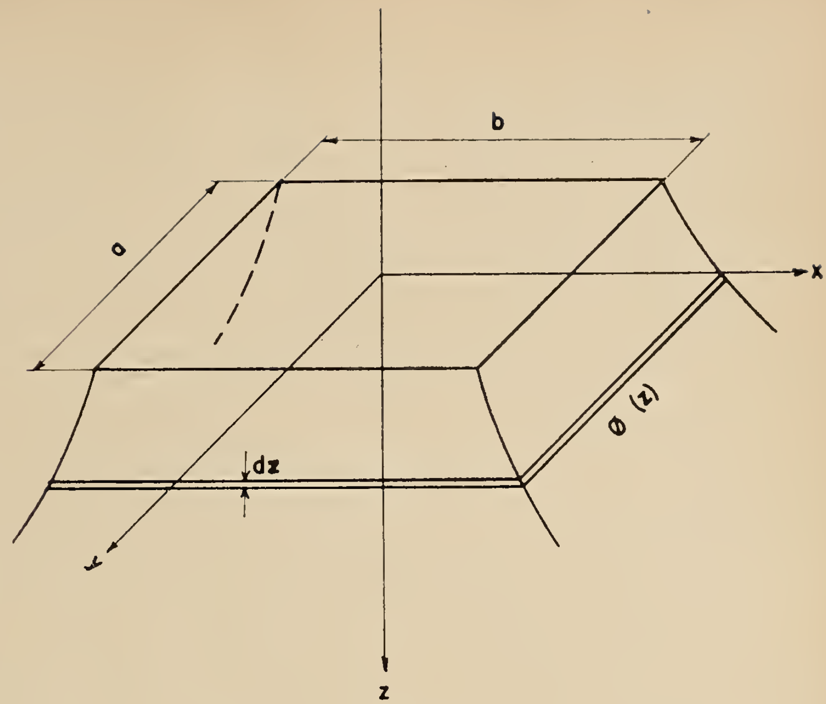

Fig. 1.

(*d*) *A Method for Determining the Natural Frequencies of Machine Foundations*: As has been noted in the foregoing paragraphs there have been some attempts to determine analytically the natural frequencies of machine foundations. On the whole they have not been very successful. A procedure, based on Rayleigh's Principle, outlined in this paper, may be used to find the natural frequencies for all the degrees of freedom of rigid foundations. Analytical determination of natural frequencies for rotational vibration about various axes is usually not practicable because of the unavailability of the values of mass moments of inertia of machines. For this reason the application of the method to vertical and horizontal vibration, only, is given here.

In determining the natural frequency of vertical vibration the assumptions and procedure are as follows:

Assumptions

(1) The system may be considered conservative in order to determine natural frequencies;

(2) Dynamic pressure is transmitted through soil contained in a solid formed by the base of the foundation and the surfaces

$y = f(z)$, $y = -f(z)$, $x = \phi(z)$, and $x = -\phi(z)$

as shown in Fig. 1.;

(3) The dynamic stress at any depth z is uniformly distributed over a section of the solid parallel to the (xy) plane, that is, parallel to the base of the foundation.

The last assumption is inaccurate but is useful for the development of relations which are at best dependent on empirical data.

The notation is as follows:

M = mass of foundation and machine

ρ = density of soil (mass per unit volume)

a = width of foundation

b = length of foundation

A = bearing area of foundation $= ab$

W_{0f} = amplitude of vibration of foundation

f_z = natural frequency for vertical vibration

ω = angular natural frequency

E' = dynamic modulus of elasticity of soil

G = dynamic shear modulus of soil

ν = Poisson's ratio of soil

σ_z = vertical normal stress (dynamic) in z direction

Consider an elemental layer of soil at depth z as shown in Fig. 1.

Let the amplitude of vibration of this layer = W_0.

W_0 decreases as z increases.

Let W_0 be given by :

$$W_0 = W_{0f}e^{-\beta z}$$

β(decay factor) is dimensionally equivalent to L^{-1}

Assume foundation vibrates sinusoidally :

$$W_f = W_{0f}\sin\omega t$$

The maximum kinetic energy of the foundation and machine is given by :

$$T' = \tfrac{1}{2}M\omega^2W_{0f}^2$$

It is now necessary to find T″ the maximum kinetic energy of the vibrating soil.

Let amplitude of dynamic strain at $z = 0$ be ϵ_{z0}.

$$\epsilon_{z0} = \left|\frac{\partial W_0}{\partial Z}\right|_{z=0}$$

$$= \beta W_{0f}$$

Let s be area of layer of elemental thickness at depth z. Amplitude of dynamic strain at z is given by :

$$\epsilon_z = \left|\frac{\partial W_0}{\partial Z}\right|$$

$$= \beta W_{0f}e^{-\beta z}$$

Equating the force acting on contact area ab, to the force acting on elemental layer gives :

$$E'\beta W_{0f}e^{-\beta z}S = \beta W_{0f}abE'$$

$$\therefore\ S = abe^{\beta z}$$

Assume the elemental layer vibrates as follows :

$$W = W_0\sin\omega t$$

The maximum kinetic energy of the elemental layer is given by :

$$dT'' = \tfrac{1}{2}\rho abe^{\beta z}\omega^2W_0^2dz$$

$$= \tfrac{1}{2}\rho abe^{-\beta z}W_{0f}^2\omega^2dz$$

∴ The maximum kinetic energy of the soil is

$$T'' = \tfrac{1}{2}\rho abW_{0f}^2\omega^2\int_0^\infty e^{-\beta z}dz$$

$$= \frac{\rho abW_{0f}^2\omega^2}{2\beta}$$

The maximum kinetic energy of the system is then given by :

$$T = T' + T''$$

$$= \frac{\rho abW_{0f}^2\omega^2}{2\beta} + \frac{M\omega^2W_{0f}^2}{2}$$

$$= \frac{W_{0f}^2\omega^2}{2}\left[\frac{\rho ab}{\beta} + M\right]$$

Consider the strain energy of the system.

The amplitude of

$$\sigma_z = E'\left|\frac{\partial W_0}{\partial Z}\right|$$

The maximum strain energy of the elemental layer is then given by :

$$dV = \frac{|\sigma_z|^2}{2E'}$$

multiplied by the vol. of layer

$$= \tfrac{1}{2}E'\left|\frac{\partial W_0}{\partial z}\right|^2 abe^{\beta z}dz$$

$$= \tfrac{1}{2}E'\beta^2W_{0f}^2e^{-\beta z}abdz$$

Maximum strain energy is then given by :

$$V = \tfrac{1}{2}E'\beta^2W_{0f}^2ab\int_0^\infty e^{-\beta z}dz$$

$$= \tfrac{1}{2}E'\beta W_{0f}^2ab$$

For a conservative system, according to Rayleigh's Principle, the maximum strain energy is equal to the maximum kinetic energy.

i.e. $V = T$

$$\therefore\ \tfrac{1}{2}E'\beta W_{0f}^2ab = \frac{W_{0f}^2\omega^2}{2}\left[\frac{\rho ab}{\beta} + M\right]$$

$$\omega = \sqrt{\frac{E'\beta ab}{(\rho ab/\beta) + M}}$$

$$\therefore\ f_z = \frac{1}{2\pi}\sqrt{\frac{E'\beta ab}{(\rho ab/\beta) + M}}$$

$$G = \frac{E'}{2(1+\nu)}$$

$$\therefore\ f_z = \frac{1}{2\pi}\sqrt{\frac{2G(1+\nu)\beta ab}{(\rho ab/\beta) + M}} \qquad (1.3)$$

$$\text{or}\quad f_z = \frac{1}{2\pi}\sqrt{\frac{2G(1+\surd)\beta g}{(\gamma/\beta) + p}} \qquad (1.4)$$

in which

α = weight density of the soil

p = bearing pressure

g = acceleration of gravity

The natural frequency of the foundation is therefore dependent on the physical properties of the soil, the bearing pressure and the decay factor β.

The decay factor β may be determined from the equation

$$\beta = \frac{B}{m\sqrt{A}(1-\nu^2)}\ \text{ft}^{-1} \qquad (1.5)$$

In which

A is the area of the foundation in square feet

m is a constant given in Table I

ν is Poisson's ratio

Table I

Timoshenko and Goodier[7]

Table of Factors m in Eq. (1.5)

					Ratio a/b			
	Circle	*Square*	*1.5*	*2*	*3*	*5*	*10*	*100*
m	0.96	0.95	0.94	0.92	0.88	0.82	0.71	0.37

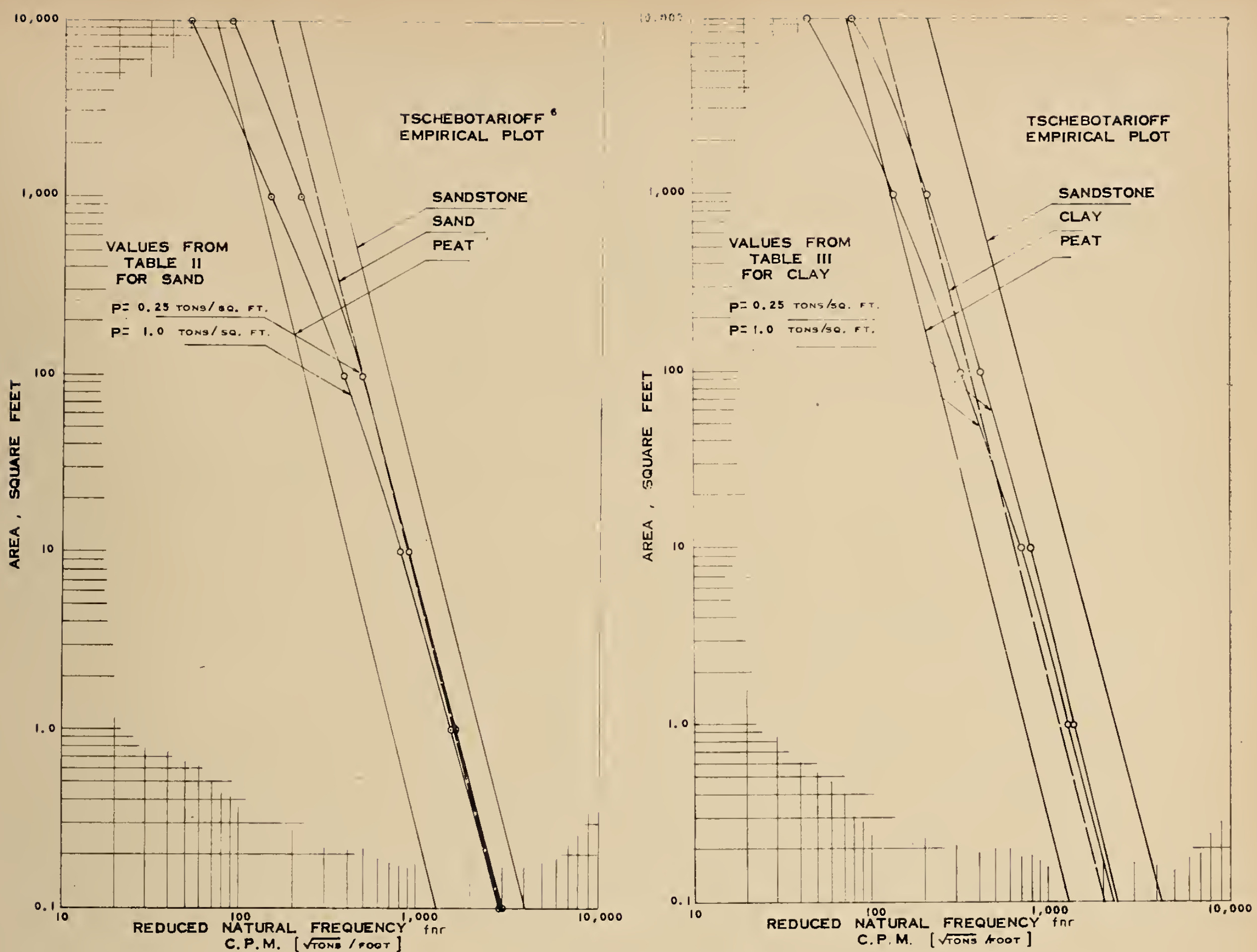

Fig. 2. Comparison of the Values given in Table III with the Empirical Plot by Tschebotarioff.

The derivation of equation (1.5) is given in Appendix 1.

For sand, the decay factor β may be taken as

$$\frac{2.0}{m\sqrt{A}(1-\nu^2)}\text{ft}^{-1} \quad (1.5a)$$

For clay the decay factor β may be taken as

$$\frac{1.5}{m\sqrt{A}(1-\nu^2)} \quad (1.5b)$$

In order to consider the natural frequency for horizontal vibration in the x and y directions of Fig. 1, the same assumptions as before are made along with the assumption that the dynamic shearing stress is uniformly distributed over a section of the solid parallel to the xy plane.

Following a similar procedure the horizontal natural frequency of the foundation may be expressed as:

$$f_x = f_y = \frac{1}{2\pi}\sqrt{\frac{Gab\beta}{(\rho ab/\beta)+M}} \quad (1.6)$$

$$\text{or } f_x = f_y = \frac{1}{2\pi}\sqrt{\frac{G\beta g}{(\gamma/\beta)+p}} \quad (1.7)$$

Newcomb[3] states that the natural frequency for horizontal vibrations is usually very nearly equal to the vertical natural frequency. It is, therefore, evident that if equations 1.4 and 1.7 are compared, β is probably greater for horizontal vibration than for vertical vibration.

Equation 1.4 has been used to determine the natural frequency of machine foundations whose areas range from 1 sq. ft. to 10,000 sq. ft., and bearing pressures from 0.25 tons per sq. ft. to 1 ton per sq. ft. In carrying out the computations it was assumed that the foundations were resting either on sand or on clay. The constants used in the computations were as follows:

Constant	*Sand*	*Clay*
G	2000 p.s.i.	1500 p.s.i.
ν	0.33	0.5
g	32.2 ft/sec²	32.2 ft/sec²
γ	130 lb./ft³	110 lb./ft³
β	equation 1.5*a*	equation 1.5*b*
p	as given	as given

The results of the computations are compiled in tables II and III.

The values given in tables II and III are plotted in Fig. 2 and compared with the empirical plot of Tschebotarioff[6].

Conclusions

1. It is apparent that the behaviour of a machine foundation cannot be considered as analogous to a simple spring mass system with or without viscous damping and linear elasticity.

2. The resonant frequency is independent of the dynamic force.

3. The resonant frequency decreases with an increase in bearing pressure.

4. The method presented in this paper permits the determination of the resonant frequency of a machine foundation by considering the physical properties of the soil, the dimensions of the foundation, and the bearing pressure on the soil. There is a reasonable

agreement between the results so obtained and those given by the empirical plot of Tschebotarioff.

Acknowledgements

The writers wish to express their thanks to the National Research Council for the Research Associateships awarded to Mr. Haddow during the summers of 1956 and 1957, when the work outlined in this paper was carried out. Thanks are due to Dr. R. M. Hardy who introduced the writers to the topic and to Mr. J. S. Kennedy for reviewing the paper.

Appendix I

Derivation of Equations (1.5), (1.5a) anp (1.5b).

Consider the model shown in Fig. 1 to be loaded with a dynamic load P uniformly distributed over the surface area A.

The dynamic stress at depth z is given by:

$$\sigma_z = \frac{P}{S} = \frac{P}{abe^{\beta z}}$$

The unit strain at depth z is given by:

$$\epsilon_z = \frac{P}{E'abe^{\beta z}}$$

Let W' be the deflection at $z = 0$

$$W' = \int_0^\infty \frac{Pdz}{E'abe^{\beta z}} = \frac{P}{E'\beta A}$$

The vertical deflection of a rigid foundation, resting on an elastic medium, is very nearly equal to the average deflection of a uniformly loaded surface of the same dimensions with the same total load. This deflection is given by Timoshenko and Goodier[7] as

$$W = \frac{mP(1 - \nu^2)}{E\sqrt{A}}$$

where m is a constant dependent on the length to width ratio of the foundation (Table 1).

Put $W = W'$ and $E = BE'$

in which B is a constant to be evaluated for different soils,

then $$\frac{BP}{E'\beta A} = \frac{mP(1 - \nu^2)}{E'\sqrt{A}}$$

$$\therefore \quad \beta = \frac{B}{m\sqrt{A}(1 - \nu^2)}$$

The constant B may be evaluated from vibrator results or field data. The available information would indicate that reasonable values for the constant B may be taken as 2.0 for sands and 1.5 for clay.

Table II

Natural Frequency f_n and

Reduced Natural Frequency f_{nr}* for Foundations on Sand

Area sq. ft.	*Frequency*	*Bearing Pressure Tons per sq. ft.* 1	0.75	0.50	0.25
1	f_n	1640	1880	2280	3140
	f_{nr}	1640	1630	1610	1570
10	f_n	890	1020	1220	1590
	f_{nr}	890	880	860	790
100	f_n	460	510	660	720
	f_{nr}	460	440	420	360
1,000	f_n	210	230	250	270
	f_{nr}	210	200	180	140
10,000	f_n	85	90	92	96
	f_{nr}	85	78	65	50

* $f_{nr} = f_n\sqrt{P}$

Table III

Natural Frequency f_n and

Reduced Natural Frequency f_{nr}* for Foundations on Clay

Area sq. ft.	*Frequency*	*Bearing Pressure Tons per sq. ft.* 1	0.75	0.50	0.25
1	f_n	1400	1620	1960	2700
	f_{nr}	1400	1400	1390	1350
10	f_n	770	875	1040	1400
	f_{nr}	770	760	740	700
100	f_n	390	450	520	625
	f_{nr}	390	390	370	310
1,000	f_n	190	200	220	250
	f_{nr}	190	180	160	130
10,000	f_n	75	78	80	85
	f_{nr}	75	70	60	45

* $f_{nr} = f_n\sqrt{P}$

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Discussion

BACKWATER COMPUTATIONS FOR THE ST. LAWRENCE POWER PROJECT

Part A—Hydraulic Engineering Aspects of Computations

H. M. McFarlane,
Hydraulic Design Engineer, Ontario Hydro, Toronto

The Engineering Journal, February 1960, page 55.

Discussion by T. R. Anand

Mr. H. M. McFarlane's paper describing the theoretical, procedural and technical aspects of a major backwater study with the help of computers is very interesting. Being one of the first extensive uses of computing devices in the hydraulic field in Canada, the study and the experience gained is very valuable indeed.

The writer is in agreement with the formulae used for bend losses, expansion losses and friction losses, but wishes to comment on formulae adopted for interpolation of computations. On page 59 was given:

$$h_{f_2} = \left(\frac{2n_2}{(n_1/h_{f_1}^{1/2}) + (n_3/h_{f_3}^{1/2})}\right)^2 \qquad (1)$$

Where h_{f1} and h_{f3} are computed friction losses for assumed roughnesses n_1 and n_3 respectively, and n_2 is the selected roughness for which friction loss h_{f_2} is required; n_1 and n_3 bracketing n_2.

The basis of this proposed formula is the Manning Formula:

$$Q = \frac{1.486}{n} AR^{2/3} \cdot S^{1/2}$$

or $$Q = \frac{1.486}{n} AR^{2/3} \frac{(hf)^{1/2}}{l^{1/2}} \qquad (2)$$

or $$\frac{n}{hf^{1/2}} = \frac{1.486}{Q \cdot l^{1/2}} \cdot AR^{2/3}$$

Substituting this value of $n/(hf)^{1/2}$ in formula (1) for the values of $n = n_1$ and $n = n_3$.

$$h_{f_2} = \frac{2n_2}{\frac{1.486}{Q \cdot l^{1/2}}\left(A_1R_1^{2/3} + A_2R_2^{2/3}\right)} \qquad (3)$$

or

$$\frac{n_2}{h_{f_2}^{1/2}} = \frac{1.486}{Q \cdot l^{1/2}} \cdot \left(\frac{A_1R_1^{2/3} + A_2R_2^{2/3}}{2}\right)$$

Comparing (2) and (3) it can be seen that formula (3) and hence formula (1) is written for a mean value of conveyance factor $AR^{2/3}$. In other words, the formula given by Mr. McFarlane is strictly true for a value of $AR^{2/3}$ midway between the values for $A_1R_1^{2/3}$ and $A_2R_2^{2/3}$. In actual cases presented by the paper, the chosen value of n for interpolated backwaters is not always the average of values n_1 and n_3 originally chosen. If the divergence between n_1 and n_3 is small and the river section has no abrupt changes, the interpolated values may not differ very much from manually worked out values for n_2. But, if river section has abrupt changes, e.g., islands or sudden enlargements between the bracketing values of conveyance factor, or the value n_2 chosen is significantly different from mean of values n_1 and n_3, corresponding differences would show up in backwater calculations. The author has mentioned a divergence of interpolated values from manual computations. Perhaps it would be advisable to study this divergence in the light of above remarks. The writer is unable to do so for want of actual data.

The use of hydraulic models has been mentioned to verify backwater curves. If the roughness of channels with and without improvements are accurately known and the model constructed to correspond to these roughnesses, such verification may be possible with a fairly large scale model. Otherwise, step-by-step computations usually give results as reliable as any.

Author's reply

I should like to thank Mr. Anand for his discussion of my paper.

Mr. Anand is correct in his conclusion that the interpolation equation referred to above is strictly accurate only if $A_2 R_2{}^{2/3} = \frac{1}{2} (A_1 R_1{}^{2/3} + A_3 R_3{}^{2/3})$ (a)

When carrying out the backwater computation, it was realized, of course, that use of the interpolation equations could introduce small errors in two ways;

1. Without a knowledge of the finally selected channel roughness n^2, it would be most fortuitous if the chosen values of n, and n^2, were such that equation (a) above would be satisfied.

2. The computed profiles to be modified by interpolation include both bend and expansion losses in addition to pure friction losses.

It was felt, however, that the urgency for obtaining backwater slopes in the headpond would not permit delaying computations until the actual channel roughness could be determined, which would have eliminated the necessity for interpolation. In addition, no practical method for separating bend and expansion losses from pure friction losses was evident. Thus it was decided to interpolate the total loss and to make several check computations to determine whether a serious error resulted. As it happened, the results of these checks indicated that errors introduced by the interpolation methods were very small.

The Hydraulic Models for the project were used for many purposes in addition to verifying the backwater curves. One of the more important uses was in redesigning the extensive channel enlargements which were to be made between Chimney Point and Morrisburg. For this purpose a Hydraulic Model is invaluable, since it permits rapid changes to be made in various segments of the enlargement plan until the optimum design is achieved. Since the models were being used to redesign the channel enlargements, they also were used to provide backwater slopes in the areas in which the revised enlargements occurred.

THE PRINCIPLES OF AUTOMATIC CONTROL

A. Porter, M.E.I.C.,
Dean of Engineering, University of Saskatchewan.

The Engineering Journal, September 1960, page 53.

Discussion by G. S. Glinski

(Continued on page 119)

Automation and Control Engineering in Canada

The Instrumentation & Control of Central Steam Power Stations

L. G. Holman
Montreal Engineering Company, Limited, Montreal.

DURING the past decade, in common with many of the process industries, the operation of central steam power stations has necessarily been modified by the changing needs of electrical utilities. The new demands of industry were largely the result of increased capital investment due to the larger and more complex prime movers and thermal cycles being installed to meet the post-war growth in electric power requirements. The greater financial risks associated with damage to major plant, and the consequent loss of generating capacity, have led to the establishment of new standards of control and a wider degree of protection than hitherto had been found necessary. The elevated conditions of modern thermal plants and the continued downgrading of residual fossil fuels have created new problems in the operation of steam plant, with risks of costly and frequent maintenance. In addition to the need for safer operation, increasing operating costs also have encouraged the use of instrumentation to obtain optimum cycle performance and to economize in manpower.

Significant progress made in the development of new equipment and techniques, in its application to central station instrumentation, has contributed to the achievement of these objectives. Although the goals of minimum operating expenditure, improved reliability and more efficient use of personnel must remain, there have been changes in emphasis due to the changing needs of industry.

In its broadest sense instrumentation in central steam stations is used to control the operating cycle, to provide records for trend observations and history and to check the plant performance. Progress has been made from local rudimentary control to the remote central control centre with miniaturisation of instruments, perhaps electronic controls and automatic data processing. The "computer" controlled stations are to be commissioned shortly. This continual change has developed a need for a new kind of steam plant operator with new skills and outlook. It has resulted in remarkable improvements in the kilowatts per man ratio.

How effective these changes have been is adequately demonstrated by the delivered cost of power which remained remarkably stable for many years. With this successful record it would seem difficult to justify further efforts. But continued progress is needed to keep pace with ever-mounting costs, and the continued demand for more power, coupled with economic pressure to maintain the low cost of delivered power. Because of rising costs for material, fuel and labour, outdated equipment and methods will not produce at to-day's rates.

Although the capital cost per kilowatt installed decreases as units get larger and pressures and temperatures are elevated, the complexity of the unit increases. This in turn creates operating problems. Minute percentage losses, normally insignificant on small units, take on greater annual dollar values. Therefore, if minimum operating expenditure is the objective, it becomes more important to ensure that the unit is meeting its design conditions and that any deviation in performance is detected and evaluated. To secure improved reliability, sufficient information must be made available to the operator. The tools must be supplied to protect the multi-million dollars invested.

Operational Factors

Experience and thorough studies of central stations have revealed that for most modern thermal generating plants the central control centre generally results in the most efficient use of operating personnel. Unit size has little or no bearing on the number of personnel required to operate the unit. Obviously such factors as fuel firing equipment, and whether the station is on base-load service or two-shift service, are more important in determining the number of operators.

As steam-electric generating units have increased in size and complexity the tendency has been to provide more instrumentation and control. Thus, to-day's station has sophisticated control loops unknown until recently. The instrumentation provided for a given unit should be roughly the same irrespective of the rating — except for minor differences due to such factors as feed heating system and fuel fired — as the same number of functions must be performed. Thus the ratio of dollars per kilowatt has little or no meaning as far as instrumentation is concerned. As a result a most comprehensive scheme can be provided for about $1.5 per kilowatt for a 200 Mw unit whereas the minimum central control requirements for a 20 Mw unit will cost about $4 per kilowatt installed. (See Fig. 1).

A highly skilled operator thoroughly conversant with all the operational aspects of boiler, turbo-generator and associated auxiliary plant is usually in charge of the central control room. The number of his plant assistants varies with the number of units in service and the degree to which remotely-operated equipment has been applied. The amount of remotely-controlled plant which can be economically justified depends largely on the frequency of its operation and the importance of the standby equipment to the continued operation of the station. One approach commonly in use is that only major auxiliaries such as boiler feed pumps together with associated valves should be remotely operated. Secondary auxiliaries remain locally operated as in a conventional steam plant. This is to avoid the questionable expense of motorizing the multiplicity of valves, which are frequently quite small, to isolate or control auxiliaries and also to conserve control room operating surface which usually is at a premium. In the modern minimum-staffed station this method can be employed on the assumption that normal and emergency shut-downs and hot restarts can be safely achieved by the normal shift complement. A cold start-up may be planned so that additional personnel can be on hand to perform the many manual functions involved after prolonged shutdown.

Central Steam Station Instrumentation

The trend to central control schemes with minimum operating personnel established a need for an array of plant information readily accessible to the operator. Provision of the extra data required for remote operation with conventional instrumentation is extravagant both in control panel area and control room space. The result is that a single operator would be unable to supervise the overall unit properly and perform the remote manual functions adequately. It was a natural development that various degrees of miniaturisation of panel-mounted instruments occurred and that various forms of telemetering displaced the traditional methods of remote indication. This has the added advantage that high-pressure instrument-impulse lines are kept away from the control room area with elimination of possible hazards and reduction of instrument-installation costs. The end product of this progress has been that remote console type control centres are being used instead the usual vertical instrument panels. In Canada there are at least two successful examples of this form of control installation where one operator and two helpers are in charge of two complete boiler-turbo-generator units with auxiliaries.

In this type of application, indicators, boiler control instruments, burner controls, generator and auxiliary control switches are placed immediately at the operator's finger tips on what might be termed the working surface of the console. The recorders used for trend purposes are located adjacent to this area. Other recorders for historical and performance records, and annunciators are placed in less prominent areas. These new methods of designing control desks have resulted in startling reductions in the length of desks. A modern console for the control of a complete boiler, turbo-generator and auxiliaries unit can be as short as six feet. It is readily understandable that such a desk can be supervised easily without strain or unnecessary movement providing the arrangements and grouping of the instruments and control stations is a logical presentation of the operating procedure.

As already shown the changes in instrumentation have been largely logical developments of already well proven practices in areas where shortcomings had been revealed in applications for power plant service. With the advent of remote central control rooms, transmission of impulse signals became a problem as units were installed further away from the control centre, so directly connected instruments could no longer be used. In order to avoid long high-pressure impulse lines, transmitters now send pneumatic or electric signals to the receiving instruments and controllers in the control room. This method has the advantage that except for transmitters, which are usually rugged, most plant instrumentation can be located in the improved control room environment unaffected by dirt, heat and vibration.

Generally, instruments now in use are developments of measuring techniques which previously were not sufficiently reliable for powerhouse service. Refinements made possible more ambitious schemes. Probably the most outstanding example is the almost universal practice nowadays of providing oxygen and combustible gas analysers to monitor the combustion process to secure not only efficient operation but maximum safety. While frequently gas sampling still presents problems, under some conditions this type of instrument is often used to initiate a final combustion control impulse. Closed circuit television has also become a useful tool in the remote supervision of furnaces and steam drum water level.

The increasing use of higher steam pressures and temperatures demands greater attention to chemical conditions of steam, feedwater and condensate. The constituents of these media are still largely determined on a routine basis by chemical means in the laboratory. However, there is a greater tendency to employ continuous determination and recording methods to avoid the possibility of overlooking deteriorating conditions of a transient nature between sampling periods. There is also the desire to reduce the tedious and time-consuming laboratory work and to obtain consistently accurate results. Sometimes after satisfactory results with this kind of instrumentation the scope has been widened to regulate the injection of corrective chemicals on a continuous basis to maintain the desired protective residuals.

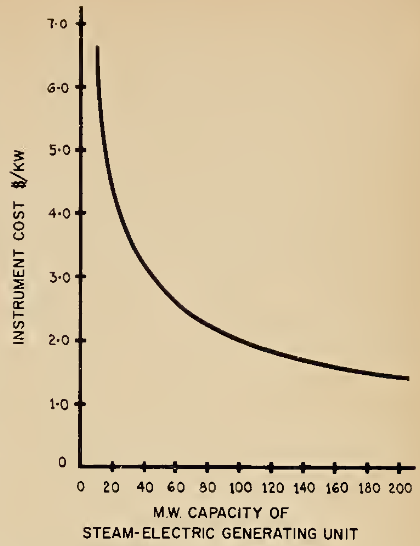


Fig. 1. Approximate instrument cost — Central Controlled Unit.

Generally, instrument trends have been from direct reading to telemetering of one sort or another, from full size to miniature and from local control of major plant to remote panels in the central control room. New instruments coming into use are components eventually for use in control loops previously regulated by hand on the basis of experience and judgement.

Central Steam Station Control

Control systems in steam power stations are expected to respond to all load demands on the unit while maintaining optimum efficiency. They will protect the unit from improper operating conditions in furnaces and from stresses due to undue variations of pressure and temperature. These requirements differ from the duties performed by control systems in process industries where a relatively constant throughput or load is maintained.

The various controls applied to steam-electric generator units have undergone development and variations to meet changing situations and the following is intended to review the more important innovations.

(a) *Master Control:* The established practice of interconnecting all boilers and turbines in a station has given way almost entirely to the unit system consisting of one boiler — one turbo-generator unit with all of its own associated auxiliaries. This simplifies the "Master Control", since the unit is unaffected by thermal changes of the other boilers and turbines. The Master controller settings are made to suit the thermal response of its individual steam generator. The advent of the unit system in central steam stations has resulted in a drive to achieve better response to load changes at the generator. The first major success came with the development of a two-element master control (See Fig. 2a) which uses the influences of steam pressure and steam flow to produce a corrective control signal representing both direction and magnitude of the variations in load. Although there are many units successfully employing two-element master control systems it was recognised that the best response would only be obtained when the changing load on the generator was used as a primary impulse for master control.

A number of unique factors associated with the operation of supercritical pressure "Once Through" steam generators have led to the introduction of the Direct Energy Balance method of control. (See Fig. 2c). As shown in Fig. 2a and 2b, it has been the normal practice in conventional control schemes to regulate the turbine governor to meet the desired generator electrical *output* and to maintain steam pressure by adjusting the *input* of fuel and air to the boiler. Thus in these schemes the boiler firing rate follows the turbine demands. While these well-tried methods have generally proven satisfactory, particularly where boiler units have relatively large thermal storage capacities, advances in boiler design have indicated that supplementary devices, to anticipate load changes, are desirable.

The so-called Direct Energy Balance method of control is one attempt to overcome the shortcomings of conventional systems. As shown in Fig. 2c, this method relies on regulating the *input* of fuel and air to the boiler to give the desired generator electrical *output* with steam pressure maintained by regulation of the turbine governor.

(b) *Combustion Control:* Combustion control might be defined as regulation of fuel and combustion air supplies to the furnace to meet the load demand and to ensure optimum combustion efficiency. This is still substantially true but as the combustion process and furnace equipment has increased in complexity, control systems have necessarily become more intricate. The additional requirements of safety are becoming more prominent, as it has been estimated that the chances of a boiler being damaged by furnace explosion during its lifetime are at least three to one. In the interests of fuel economy, closer tolerances are placed on excess combustion air. This means that operation is closer to the process of incomplete combustion. It is, therefore, mandatory that deviations from the control point are virtually eliminated.

In the quest for more definite control of fuel and air and checks to prevent the formation of explosive combustible mixtures, supplementary actions such as fuel limiting control have been used to over-ride "Master Control" when necessary. Of these, probably the most interesting is the gradual adoption of the oxygen analyser as a fuel combustion control trimming action. Early attempts were somewhat unsuccessful for many reasons. The main reason was the unreliability of the gas sampling system and the high maintenance factor of the analyser and its associated equipment. While these faults are still largely present, ways of avoiding difficulty are now commonplace. The oxygen analyser is a particularly useful tool when firing multiple fuels since the oxygen in flue gas values is very similar for all fuels. Nevertheless an oxygen trimming control system must recognize that different excess air values are required for different loads throughout the load range and with different fuels and the various combinations of fuels in the multi-fuel fired furnace. Provision also must be made for the analyser to be removed from the control loop for servicing. All of these features contribute to very complicated control schemes with probable sacrifices in simplicity and reliability.

Though not strictly a part of combustion control, this article would be incomplete without reference to lighting off and firing sequences and interlocks which of necessity are closely allied in an integrated combustion control scheme. The central station shift operator confronted by a console covered with a multiplicity of control devices and instruments obviously must be given assistance in following the correct sequence of operation, where this is possible without compounding control components at the expense of reliability. The philosophy of permissive control and interlocks is a very controversial subject. In the face of more complex cycles and operating sequences with greater chance of injury to plant and personnel as the result of even minor operating errors, even the most avid opponent of this form of control is apt to welcome the protection offered. The arguments against the various hardware upon which these systems depend are gradually fading as experience is gained and suitable equipment becomes available.

The schemes which can be provided are almost infinitely variable and could form the subject of a complete study. Electric utility operators have a prime interest — to produce electric power continuously. Nuisance shutdowns cannot be tolerated. Consequently sequential circuits and interlock systems always are designed with absolute reliability as a basic requirement. The principle generally adopted during a correct operating sequence must first be traced and carefully studied on a step-by-step basis. Each function is related to its succeeding step and a decision made as to whether progress should be made on a permissive basis, i.e., when one manual function has been completed the monitoring circuit permits progress to the succeeding step; or whether the first and following steps can be sequenced automatically from one initiating manual action. Power Station practice is usually a combination of both methods.

In the power industry the control circuit generally uses the station batteries as the DC power source as this is the most reliable power supply available in the plant. Other users sometimes prefer AC supplies for this service because AC is compatible with other equipment, and components are then also standard "off-the-shelf" items. Flame monitoring devices are becoming more popular on large multiple burner boilers as alarm devices for selected fuels and the future is certain to bring an extension of this practice with practical application of these devices and as newer versions become available.

(c) *Feedwater Control:* The three-element feedwater control using the combined influences of Steam Flow, Feedwater Flow and Steam Drawn Water Level is almost universally used in central steam stations and is probably the most successful control loop in the automatic boiler control system. From the control point of view, problems are relatively few and where they do occur are usually caused by characteristics of particular boilers. With the higher pressures in use today, extremely high pressure drops across the feedwater control valve are apt to give rise to damage to inner valve components and valve bodies. This is so particularly during start-up when the valve is subject to the full pressure drop of the boiler feed pump shut-off head. To reduce the damage during start-up, boiler filling valves specially designed to withstand the excessive pressure drop service are being used in conjunction with boiler filling pumps of smaller capacity.

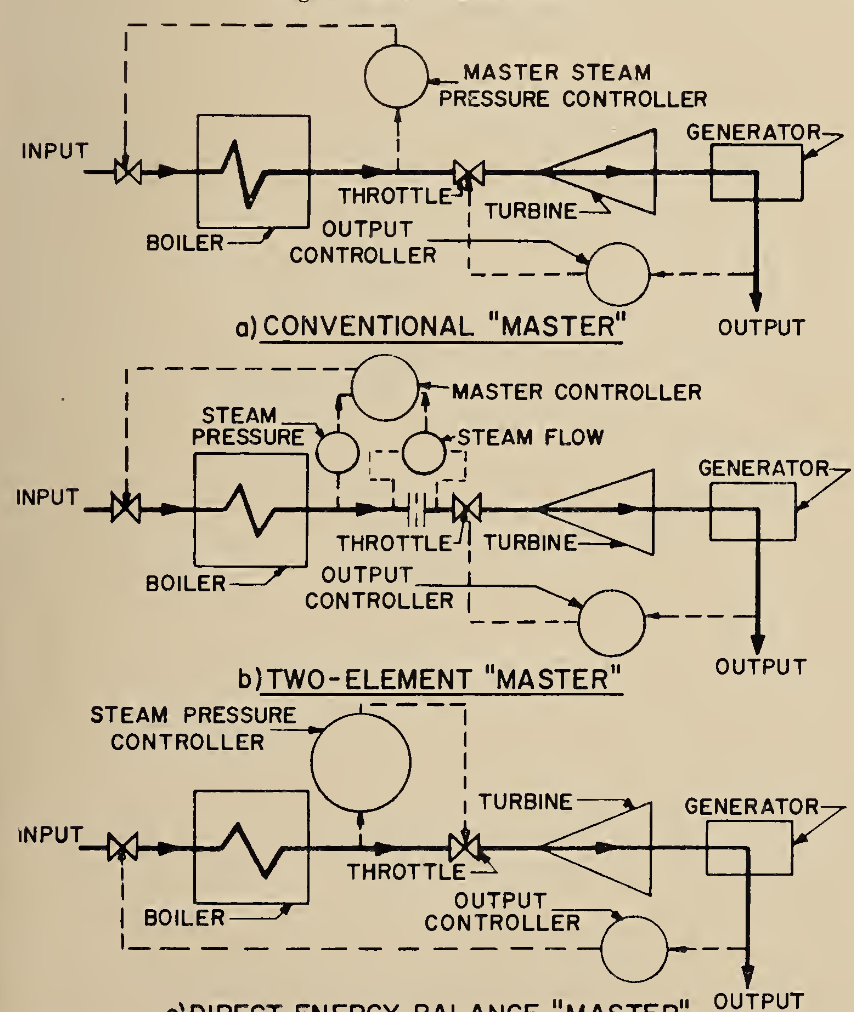
With the large units now being installed, direct connected remote water level gauges can no longer be used due to the great length of impulse lines. Consequently level transmitters are used to transmit to remote points. These transmitters usually incorporate some form of density correction to overcome the problem of incorrect readings associated with higher working pressures.

(d) *Steam Temperature Control:* Every steam temperature control seems to have its individual difficulties but these can be minimized by sufficient care during the design stages. Some of the problems are unquestionably related to the slow response of the initiating element. By necessity, the well in which the bulb is installed is heavily constructed, adequate for the service conditions, which may involve considerable time lags. Although temperature control is always the most difficult loop in any process to apply successfully, the development of multiple element control using some influence such as air flow through the unit as an index of load and heat transfer conditions, has resulted in considerable improvement. Such an influence, by its nature, has the disadvantage that the control loop is affected before the set-point has been achieved. This can be overcome by using some form of indexing system to eliminate the air flow signal until the required steam temperature has been reached.

In order to obtain wide range of control of superheat temperature it is quite common to combine sequentially attemperation or desuperheating with flue gas re-circulation or burner tilt. This is to avoid the excessive quantities of desuperheating spray water, with obvious repercussions in the form of superheater deposits, which would be required to cover a wider load range.

(d) *Miscellaneous Control Systems:* Throughout the powerhouse there are increasing numbers of simple control systems taking over the many functions previously operated manually and continuously. These various pressure, temperature and level controls now are usually installed and operate after commissioning with little care except routine maintenance.

Fig. 2. Forms of Master Control



Automation in Central Stations

Today's modern steam power station has units electronically controlled and provided with data logging equipment. There can be little doubt that many stations will be fully automatic within the foreseeable future and in this context "automatic" does not mean "manless". The central station now is in a transition period and the majority of new installations will take steps part of the way towards the ultimate goal of total automation. There is fairly common agreement throughout utilities that the concept of the automatic station has gone further and faster than expected, and probably too fast for the present state of the art.

From a theoretical viewpoint there is no reason why a system cannot be provided to start up a unit automatically by push button. The main limiting factor is the complexity of the equipment required to perform the operation together with the analyses, programming and computing associated with the automatic operation and monitoring functions required.

In the light of this extremely intricate equipment it would be well to consider how often these start-up and shut-down functions would be used during the life of the unit after the initial commissioning.

There are two basic approaches to the automatic station.

(a) Digital Computing equipment is used to program start-up, shut-down, logging and optimize the control cycles and Analogue computing equipment, which is well proven, controls the cycle in operation, i.e., the existing analogue controls remain in their entirety. This is sometimes referred to as the "Time shared Approach";

(b) A large high-speed digital computer is employed to perform and monitor all the operations required in a power station, including all the functions listed under (a) above. This method besides being probably the most expensive, introduces a more complex digital computing system with the possibility of less reliability.

In both cases the short-comings of hardware available at the present time i.e. solenoid valves, pressure switches, relays, are likely to jeopardise the success of these highly ambitious projects but in the long run there is no doubt that these problems will be overcome successfully.

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Canadian Developments

National Research Council Develops Radio Direction Finder

Research in cathode ray direction finding has been carried on in Canada for 40 years. Recently a highly-developed instrument using a twin-channel receiver concept was developed at the National Research Council and now is in production for the Navy.

A report on the history and progress of the development has been prepared by C. W. McLeish of the NRC's Radio and Electrical Engineering Division.

The first research in cathode ray direction finding in Canada was conducted by General A. C. L. McNaughton and Colonel W. A. Steel between 1921 and 1925. In 1925 they were granted a patent on the twin channel direction finder.

Before the Second World War laboratory equipment covering both the low-frequency marine and the high-frequency bands were built at NRC. These were used as navigational aids and for research in locating thunderstorms. During the war, equipment for the armed services was used both as an aid to navigation and for locating transmission sources in air-sea rescue and tactical operations.

Since 1945 many sophisticated radio navigational systems have been developed which supplant direction-finding in that role. It is still required to a limited extent, however, for emergency operations.

The environment in which a system is to work affects firstly the design, and finally the limiting performance. The first design choice in the case of the new instrument being produced for the Navy was between the twin-channel receiver and the simpler single channel (azimuth scanning) receiver.

The latter was rejected on the basis that its output indication sometimes is severely affected by the modulation of the received radio signal. The azimuth indication of the twin channel receiver is independent of the character of the modulation. In the 3-30 megacycle frequency range for which the instrument is designed, sensitivity should be limited not by internal receiver noise but by external atmospheric noise. This is not difficult to accomplish with modern components but there is an additional limit set by co-channel interference.

Since there are literally thousands of signals in the band at one time a very high degree of selectivity is desirable. This is obtained easily in the twin-channel system but is restricted in single-channel systems by the rate of scanning they employ.

Finally, all direction finding systems which operate at frequencies where the radio waves are propagated via the ionosphere depend for accuracy on the roughness and variability of this reflecting medium.

The limit, which is close to one degree (rms error) may be achieved with a very large and expensive receiving antenna which samples the radio field over many wave lengths. A narrow aperture (fractional wavelength) antenna can provide bearings with an accuracy of about three degrees (rms error) on long distance transmissions. The errors are less than half for ground-wave signals. This accuracy is considered sufficient for normal applications, although in this respect the system does not reach the absolute limit set by its environment.

Dosco Opens Lewis M. Fulton Pipe Mill in Montreal

The Dominion Steel and Coal Corporation, Limited, has opened its new continuous weld pipe mill. The $3 million mill shares a 45-acre site beside the Lachine Canal with an electrical steel plant, a rolling mill, a wire products mill for making chain link and other types of fencing, and the industrial fasteners department.

Premier Jean Lesage opened the mill which is named after Lewis M. Fulton who first became connected with Dosco in 1911 and who retired as general manager of the plant Dec. 31, 1958.

The Montreal plant was built in 1911 by the Canadian Tube and Iron Company. Dosco started to acquire the company in 1941 and completed acquisition of controlling interest in 1943. It continued to operate as The Canadian Tube and Steel Products Company until last year when it became known as Dosco's "Montreal Works."

Since Dosco acquired the plant it has made continuous improvements until, now, it is a complete steel mill. For many years steel pipe was produced in an old butt weld pipe mill which performed well for a long period of time. Ever-increasing demands for a better product at a cheaper cost necessitated, ultimately, the scrapping of this old mill.

The new mill will provide continuous welded pipes from ⅜ in. to 4 in. in diameter, in lengths varying from 16 ft. to 42 ft., and at production rates ranging between seven and 22 tons an hour.

Canadin Nuclear Association Formed

Early in 1960 the Ontario government sponsored Canada's first conference on nuclear energy. This was called to meet the need for a clear definition and public awareness of the future promised through the peaceful uses of nuclear energy.

Discussions pointed to the need for an organization to represent all bodies concerned with the nuclear field in Canada. A result was that a small group of representatives from interested industries was appointed to study all aspects of such an organization.

Thus, the Canadian Nuclear Association was formed, and its directors now invite participation from all organizations and individuals who are, or expect to be, engaged in some phase of development or utilization of nuclear energy.

Halifax International Airport Opened

Following official opening ceremonies in the early autumn the Halifax International Airport has settled into a busy routine. The $18 million airport was opened by Hon. George Hees, then Minister of Transport.

There are three miles of runways, the longest of which is 8,800 ft. and can be extended to 10,000 ft. The five-storey terminal building cost $4.5 million. It is 1,260 ft. long and has a total area of 165,000 sq. ft.

Full travel facilities include air line offices, customs, health, immigration services, and business offices. EIC

International News

Solar Energy in France

Eighty percent of all hot water being used by a large French hotel in Perpignan in the Pyrenees is being heated by the sun. This new solar-energy heating system has been developed by the scientists of the National Center for Scientific Research at Mont-Louis, near Perpignan. They believe, according to 'France Actualle', that "if developed on an industrial scale, this could bring about a considerable revolution in energy production". They claim that mass production of heating apparatus based on this principle is already practicable and the cost would be relatively low. An industrial solar furnace at Mont-Louis has been in operation since 1952 turning out refractory products and this recent work in regard to the storing of the sun's energy was put into practice in the Spring.

At this hotel 25 special, two-square-meter mirrors, inclined at 45° angles and facing directly south have been placed on the hotel's roof terraces. They absorb infrared rays from the sun by means of specially treated sheets of metal, and heat more than 1,000 gallons of water. The water is brought to a boil on the roof of the hotel and is then piped to two basement storage tanks where a 60°C. temperature is maintained. Regular circuits then distribute hot water under pressure to all parts of the hotel. An electronic regulating device maintains the thermo-dynamic yield of this installation at a constant level, also automatically switching on an emergency central heating system in the unlikely event of there not being sufficient sun to heat the water to the proper temperature.

Obviously there are still a great many discoveries to be made in this field and the French are already constructing a second solar furnace at Odeillo, about 10 miles from Mont-Louis. It is planned this will go into operation in 1962 and is expected to produce 500 metric tons of refractory products a year at half the cost of manufacturing similar products in steel plants. A $600,000 Institute for Atmospheric Research is being built on the Lannemezan Plateau facing the French side of the Pyrenees and is sponsored by the Board of Scientific Research in France. After being transformed into a "solar-receptor area", the special covering of the 150 acres is to be heated to a high temperature which in turn will cause convective currents in the atmosphere planned to produce artificial rain. This new Institute at Campistrous is to be equipped with radar and an atmospheric goniometer.

Computer Instruction included in U.S. Engineering Courses

The University of Michigan has in the past year, been carrying out a project under which computer techniques were introduced to engineering students. The Ford Foundation last fall granted the University $900,000 for a three-year program in this field.

Forty-nine engineering courses used the computer as a regular part of course instruction and it appeared that even with a relatively small amount of computer background, students were able to solve problems assigned. Prof. Katz, who is in charge of the project, said in a report given at a conference at the University in September, that the best problems for computer instruction are yet to be found. Changes in mathematics instruction would be necessary and the project also found that the faculty must be trained in programming and solving problems themselves before assigning them to their classes. University administrations must accept the responsibility for the support of computer equipment for instruction. In the near future costs for computers for instruction are likely to match the costs of instructional laboratories, a fact which should be made clear to college administrators. An outline of the three-year program is also listed in the report.

Expected Reductions in Nuclear Power Costs

Prospects of reductions in the cost of generating nuclear power have been indicated in a report prepared by the International Atomic Energy Agency presented at their General Conference in Vienna recently. Nuclear power is still in its early phase of development and substantial cost reductions can be expected from technical improvements that are likely to emerge from the continuous research and development that is going on in several fields. Especially significant will be the possible reductions in fuel cycle costs, resulting from lower fabrication and re-processing charges, higher burn-ups and a fall in uranium prices. Development of improved but low cost reactor materials should also result in an overall economy. Savings can be expected from the standardization of reactor components. With better understanding of essential safety requirements and through the use of improved techniques, containment and control of reactors will become simplified and less expensive. Finally, when several nuclear power plants of essentially the same design are built, the engineering development expenses will be spread out and the cost per unit will decrease.

U.K. Vehicle for Road or Rail

A vehicle that may be converted from truck to rail wagon has been developed in the U.K. Made by the Pressed Steel Company, Oxford, England, this 11-ton capacity truck can be driven to the railhead and, at a touch of a button, the rear wheels retract and the rail wheels are lowered. Hitched to a freight train it travels as a rail wagon to its destination where, converted once more to a truck, it completes the journey by road.

Northern Ireland's Oil-Fired Generating Station

Coolkeeragh Power Station, Northern Ireland's first oil-fired generating station, has two 30,000 kw. sets in commission with one 60,000 kw. set to be installed for commissioning by the fall of 1961. The 60Mw. turbine-generator, feed heater, and condenser are being manufactured by Associated Electrical Industries (Manchester) Ltd. The Transformer Division of the A.E.I. has also supplied two 37,500 kva., 11,800/35,-400v., 3-phase OFW cooled generator transformers and are manufacturing a 75,000 kva., 3-phase generator transformer, with a ratio of 11,800/120,-000v. ON/OFB cooled, which will be fitted with an on-load tap-changer.

The station is designed to meet demands of future industrial development. It also will supply Londonderry city when the generating station there is closed by the Londonderry Corporation Electricity Department. EIC

Month to Month

September Executive Committee Meeting

The Institute's Executive Committee of Council, President Dick presiding, met in St. Andrews, N.B., Sept. 9. The following, taken from the minutes of the meeting, reports the highlights.

Membership List

The General Secretary was authorized to distribute bills for 1961 fees early in December. Members are also being sent a card requesting information which will enable Headquarters to classify the membership according to their fields of engineering interest. This information also will enable Headquarters to publish a membership directory early in 1961. Three thousand copies of the membership list will be produced. Copies will be distributed at no cost to universities, Branch Chairmen, Councillors, members of the Committee on Technical Operations, and others who require them. It was agreed in principle that other E.I.C. members desiring copies will be able to purchase them at a small charge.

Committee on Membership

The Executive Committee agreed on the need for a more vigorous membership program. The necessity of a national committee on membership was evident, this committee to work through the Branches and other E.I.C. facilities with the object of promoting a serious drive for new members. Finance Committee Chairman F . L. Lawton observed that the Institute is at present serving only a portion of its entire potential membership: consequently the Institute is not as strong as it should be. There is a vital need for a national membership committee, and a vital need for the strongest possible activity at all levels of the Institute.

It was resolved that a national committee be formed with S. B. Cassidy of Fredericton, N.B., as chairman. This committee is responsible for actively co-ordinating and encouraging the following specific activities of the Branches on which the prime responsibility for direct membership activities shall continue to rest:

a) Formation of active Branch membership committees by all Branches

b) Recruiting of new members of suitable calibre for the Institute

c) Investigation of cases of apparent loss of interest in the Institute affairs and activities by members as indicated by non-payment of fees, by direct complaint, by notice of intention of resigning, or in other ways. The function of the Committee in this field shall be to encourage the Branch Committees to carry such investigations to the point at which the cause of difficulties could be determined, and the matter then referred to the relevant Branch or Institute body for action

d) Investigation of reasons for unwillingness to join the Institute on the part of apparently desirable candidates where such cases come to the attention of Branch or Institute Committee members.

The Committee shall assist actively the Branch Membership Committees in the performance of their functions in establishing suitable terms of reference for operational procedures. The Committee shall provide effective liason between various Branch Committees, and act as a clearing house for information of common interest to Branches relating to membership.

The Committee shall periodically advise Council on matters relating to membership and assist in formulating policy in this connection.

Headquarters Re-Organization

The General Secretary reported that in view of the present enlarged program of Institute services it had become evident that the staff must be organized in a pattern which follows these major activities. The Institute's broad activities provide an adequate technical program, a service to increase and maintain its membership, and the necessary administrative functions that will enable all the programs to be carried out with the maximum efficiency and to render all possible assistance to Branches. Exclusive of the publications and library activities, which come under the direct responsibility of the General Secretary, there now are three major divisions of activities at Headquarters:

I *Membership Services,* under its manager, E. C. Luke

II *Technical Services,* under its manager, J. H. Legere

III *Financial,* records and other supporting administrative services under the Controller and Office Manager, T. R. Montgomery

Engineering Education

On the recommendation of the Chairman of the Committee on Technical Operations and the Chairman of the E.I.C. Committee on Engineering Education, it was resolved that the E.I.C. Committee on Education be constituted as a division of the Committee on Technical Operations; and that Dean Arthur Porter, Chairman of the Committee on Engineering Education, continue as Chairman of the Engineering Education Division of the Committee on Technical Operations.

Commonwealth Co-operation

There are many members of the Commonwealth sister societies now resident in Canada who are not members of the E.I.C. Members of such sister societies resident in Canada do not have a professional home. The E.I.C. now has in the Committee On Technical Operations and in its several divisions the organizational framework for co-operation with members of sister societies.

The councils of the four societies concerned have expressed the hope that institution members in Canada will give this plan their whole-hearted support, in the knowledge that by so doing they can take an active part in technical activities which will contribute significantly to the development of engineering in Canada.

Basis of Agreement

1. Members of other Commonwealth societies resident in Canada are invited to participate in the activities of the Engineering Institute of Canada, both on a national and local basis. Branches of the E.I.C. are encouraged to establish specialist sections and/or specialist engineering discussion groups wherever justified by numbers and interest.
2. All members resident in Canada are invited to submit papers for consideration by the appropriate Engineering Division of the E.I.C. Committee on Technical Operations for presentation at Annual, Regional and local meetings of the E.I.C. They are also encouraged to submit papers of a more local character to the E.I.C. Branch in each area.
3. Members of another Commonwealth society resident in Canada are to be represented on the appropriate Engineering Division of the E.I.C. Committee on Technical Operations, where warranted and justified by the number in that speciality and as agreed by the society concerned, by a representative appointed thereto by the governing body of the sister society. Members so nominated are to become full voting members of the

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THE ENGINEERING INSTITUTE OF CANADA

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1177 W. 33rd Avenue,
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(Continued overleaf)

President's Column

DURING the past few weeks Presidential visits have been made to the St. Maurice Valley Branch and to the Saguenay Branch. Splendid meetings were held at Shawinigin and Arvida, with good attendances at both places. Sherbrooke Branch tendered the President a Testimonial Banquet on October 29th, following the Convocation when the University of Sherbrooke awarded the President the Degree of Doctor of Science (Honoris Causa).

Many messages of congratulations were received by the President, for which he extends his sincere thanks.

A Council Meeting was held in Sherbrooke the same day.

Other Presidential activities included attendance at Queen's University when a Past President of the Engineering Institute, John Bertram Stirling, B.A., B.Sc., LLD, was installed as Chancellor. This is a great honour to a very worthy Past President and the Engineering Institute extends its sincere congratulations to Dr. Stirling on this memorable occasion.

The Engineering Institute of Canada was also represented by your President at the Annual Dinner of the R.C.E.M.E. Corps Association of which our Treasurer, Mr. E. D. Gray-Donald is President. Many members of the Institute are R.C.E.M.E. officers, including Past-President, L. F. Grant, who responded to one of the toasts.

Considerable activity has been shown by the new Committee on Membership. This very important Committee is being very effectively headed by Councillor Stan Cassidy of Fredericton, N.B. Stan is looking to every E.I.C. member to be a member of his Committee, to utilize the entire existing membership to recruit new members. While we are proud of the extent of our membership coverage we must all realize that there are still a great many engineers in Canada who should be members, and we make a special plea to all members of the Institute to constitute themselves as members of this new Membership Committee, and to extol the benefits and advantages of E.I.C. membership, with the object of bringing in new members.

The Committee on Technical Operations under Dr. Guy Ballard, Vice-President (Scientific) of the National Research Council, Ottawa, is furthering the Institute's technical activities in various directions, not the least of which is in branch activities. Our greatest contribution to our members is to make them more aware of the possibilities for their technical improvement, and this Committee is working towards increasing the interest of members and branches in this important phase of our responsibilities.

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Sec.-Treas., R. Wayne Kyle, M.E.I.C., Assistant City Engineer, Engineering Department, City Hall, Prince Albert, Sask.

Estevan
Chairman: A. Guthrie, M.E.I.C., Box 1276, Estevan, Sask.
Sec.-Treas., Gerald R. Ursenbach, M.E.I.C., Producers Pipelines Ltd., Estevan, Sask.

Saskatoon
Chairman, R. C. Strayer, M.E.I.C., University of Saskatchewan, College of Engineering, Saskatoon, Sask.
Sec.-Treas., F. W. Catterall, M.E.I.C., Underwood, McLellan & Assoc., Box 539, Saskatoon, Sask.

Yorkton
Chairman, R. G. Brown, M.E.I.C., Box 579, Yorkton, Sask.
Sec-Treas., C. L. Slegel, M.E.I.C., 83 Elizabeth Avenue, Yorkton, Sask.

SAULT STE. MARIE
Chairman, N. A. Paolini, c/o Dominion Bridge Co. Ltd., P.O. Box 520, Sault Ste. Marie, Ont.
Secretary-Treasurer, M. R. Wright, c/o Dominion Bridge Co. Ltd., P.O. Box 520, Sault Ste. Marie, Ont., Tel. AL. 6-5611.

SUDBURY
Chairman, R. P. Crawford, 218 College St., Sudbury, Ont.
Secretary-Treasurer, C. L. MacMillan, 1237 Woodbine Ave., Sudbury, Ont.

TORONTO
Chairman, A. M. Toye, 102 Bideford St., Downsview, Ont., Tel. CH. 4-2571, Loc. 492.
Secretary-Treasurer, C. L. Thompson, c/o Honeywell Controls Ltd., Vanderhoof Ave., Leaside, Toronto, Ont., Tel. HU. 9-2151.

VANCOUVER
Chairman, C. P. Jones, 4130 Capilano Rd., North Vancouver, B.C.
Secretary-Treasurer, R. Clough, 1232 Dogwood Crescent, North Vancouver, B.C.

VANCOUVER ISLAND
Chairman, L. C. Johnson, 3051 Larkdowne Rd., Victoria, B.C.
Secretary-Treasurer, R. W. Lockie, 314 Cadillac Avenue, Victoria, B.C.

WINNIPEG
Chairman, W. L. Wardrop, 456 Notre Dame Ave., Winnipeg, Man.
Secretary-Treasurer, W. N. Isberg, 39 Turner Ave., Winnipeg 12, Man.

YUKON
Chairman, J. H. Reeves, c/o Northwest Hwy. Maintenance Est., Whitehorse, Yukon.
Secretary, J. P. MacGowan, c/o Northwest Hwy. Maintenance Est., Whitehorse, Yukon.

ONTARIO DIVISION
Chairman, H. R. Sills, 542 Gilmour St., Peterborough, Ont.
Secretary, John G. Hall, 92 Heddington Ave., Toronto, Ont.

Notice

IMPORTANT CHANGE IN MEMBERSHIP PROCEDURE.

Council recently approved a change in membership application procedure whereby reports in writing will be required in future from all applicants' references (sponsors). This will be accomplished by the use of a new combination letter and form, which will be distributed BY THE APPLICANT HIMSELF to the three or more persons selected for references. The report portion will then be completed and returned directly to Headquarters by each referee.

An initial supply of these forms will be forwarded to all branches as soon as they are available, and the new system is to be introduced at once. Each applicant for membership will, therefore, be given three (more if needed) blank copies of the new form, IN ADDITION TO the membership application form.

Council is confident that this procedure will do much to improve the admission process, and at the same time guard the level of qualifications for membership.

YOUR CO-OPERATION IS REQUESTED.

1960 Annual General Meeting

Minutes of the Seventy-Fourth Annual General Meeting of The Engineering Institute of Canada, held in the Ball Room of The Royal Alexandra Hotel, Winnipeg, Manitoba, on Wednesday, May 25, 1960, between the hours of 10.00 a.m. and 12.00 noon, presided over by President J. J. Hanna, Calgary, Alberta.

Call to Order and Notice of Meeting

The President called the Seventy-Fourth Annual General Meeting of The Engineering Institute of Canada to order at 10.00 a.m. The General Secretary read the notice of the meeting, which, in accordance with Section 52 of the by-laws, had been mailed to corporate members before the Thirtieth day of April, 1960.

President's Opening Remarks

The President extended a sincere welcome to the many members who were in attendance at the meeting.

Confirmation of Minutes

It was moved by Mr. C. Fisher, seconded by Professor A. C. Davidson, and carried unanimously that the minutes of the 73rd Annual General Meeting of the Institute held in Toronto on June 8, 1959, be taken as read and adopted.

Report of Council, Report of Finance Committee, Report of Official Auditors, and Treasurer's Report for 1959

It was moved by Mr. H. V. Page, seconded by Mr. A. W. Wirth, and carried unanimously that the report of the Council, the report of the Finance Committee, the report of the Official Auditors, and the Treasurer's report for 1959, as printed in the Annual Report for 1959, be adopted.

Official Auditors for 1960

It was moved by the Treasurer, Mr. G. N. Martin, seconded by Mr. J. Benoit, and carried unanimously that the firm of Peat, Marwick, Mitchell and Company, Chartered Accountants, of Montreal, be appointed the official auditors for the Institute for the year 1960.

Report of Committees, Representatives, Branches, and the Ontario Division

It was moved by Mr. Harvey Self, seconded by Mr. E. B. Hubbard, and carried unanimously, that the reports of the Committees, Representatives, Branches, and the Ontario Division, as printed in the Annual Report for 1959, be adopted.

Nominating Committee, 1960

The General Secretary reported that the Nominating Committee for 1960 has been appointed, as listed on page 22 of the Annual Report for 1959. One member is serving on the Committee from each Branch, with Mr. John H. Budden, Montreal, Quebec, as Chairman.

Annual Meeting Council, May 24, 1960

It was noted that there were no items of business referred from the Annual Meeting of Council, except for the report of the Engineers Confederation Commission, which would be received later at this Annual General Meeting.

Proposed Amendments to E.I.C. By-Laws

The President stated that for some years it has been apparent that certain changes to the Institute By-Laws are necessary to have them conform with current practice, as approved by Council. Accordingly Council had appointed a special committee with Mr. J. S. Waddington of Brockville as Chairman, and Messrs. Janitsch and Dolphin of Belleville and Kingston, respectively, members, to prepare appropriate amendments to the By-Laws. These proposals were approved by Council and were mailed to corporate members not less than twenty-one days before this Annual General Meeting, as required by Section 80 of the By-Laws.

The President stated that the proposals were now before the membership for discussion: the members present may propose an amendment or amendments thereto, and all proposals together with such amendment or amendments as approved by the Annual General Meeting shall be printed on a letter ballot to be submitted to the corporate membership of the Institute by the General Secretary not later than two months after the meeting. An affirmative vote of two-thirds of all valid ballots shall be necessary for the amendment or repeal of existing By-Laws, or for the adoption of new By-Laws.

Section 27—Readmission: To agree with Council decision, January 1955, it is proposed that the Section be written as follows:

> "The Council, at its discretion, may re-admit . . . any person . . . provided that one year's arrears have been paid".

It was moved by Professor A. C. Davidson, seconded by Colonel L. F. Grant, and carried unanimously that this Annual General Meeting approves the amendment to Section 27, Re-admission, for submission by letter ballot to the corporate membership.

Section 35—Investments: To provide more flexibility in implementing Council's orders, it is proposed that Section 35 be written as follows:

> "Any two, the treasurer, the chairman of the finance committee, and the general secretary, or one of the above along with a member of the finance committee, shall invest the funds of the Institute as may be ordered by Council."

It was moved by Mr. E. D. Gray-Donald, seconded by Mr. T. Foulkes, and carried unanimously that this Annual General Meeting approves the amendment to Section 35, Investments, for submission by letter ballot to the corporate membership.

Section 29—Branch Representation: To clarify the apparent meaning of the present Section it is proposed that Section 29 be written as follows:

> ". . . 3 councillors from each branch having 400 and less than 601 members, and an additional councillor from each branch for each 200 members over 601 . . ."

It was moved by Mr. R. B. Chandler, seconded by Professor W. G. Heslop, and carried unanimously that this Annual General Meeting approves the amendment to Section 29, Branch Representation, for subsequent submission by letter ballot to the corporate membership.

Section 22—Journal Subscription: To agree with Council's decision, September 1959, it is proposed that Section 22 be written as follows:

> "Honorary Members, Members, Juniors, Students and Affiliates shall receive the Journal of the Institute free. Subscription charges to all others shall be as Council directs from time to time."

It was moved by Professor A. C. Davidson that the change to Section 22—Journal subscription, as proposed be deleted and the following substituted:

> "That the $4.00 per annum Journal subscription for Members and Juniors be retained, and the $2.00 per annum Journal subscription for Students be retained, and that these funds be used as follows:
>
> — of the $4.00 from the Members and Juniors
>
> a) $1.00 per Member or Junior be rebated to the Branch for use in Branch activities.
>
> b) $1.00 per Member or Junior be given to the Committee on Technical Operations to support its work.
>
> c) $1.00 per Member or Junior be used to pay in part the reasonable travelling expenses of Branch Councillors for attendance at Council meetings.
>
> d) $1.00 be put in the Reserve Funds of the Institute to be used at the discretion of Council, without recourse to the membership at large concerning its use.
>
> — Of the $2.00 from the Student members, $0.50 be allotted to each of the items (a), (b), (c) and (d) above, with the added provision that the $0.50 rebate to Branch be used solely for Student activities in the Branch."

Professor Davidson stated that it is obvious from Branch Officers Conference discussion that most Branches require more money to operate effectively. The Charter of the E.I.C. states that one of its objectives is to promote the technical welfare of the Canadian engineer: the Committee on Technical Operations is the most effective medium through which this can be done, hence the proposal that it be given the necessary funds to expand its activities. Professor Davidson stated that it is unreasonable to expect councillors, as members of the governing body of the Institute, to continue to pay their own way to meetings of Council at which the work of the Institute is conducted. If councillors are prevented from attending for financial reasons, then they are also prevented from contributing to the work of the Institute.

Professor Davidson urged the meeting to take note of the fact that the body which is strongest financially will succeed: the Institute should do everything in its power to promote the technical welfare of the Canadian engineer, to publicize his work in Canada and in the world, and to ensure that Canada's engineering achievements are not lost because of diffidence or false economy.

In seconding the motion, Mr. Harvey Self, Toronto, spoke in very firm support of the proposals put forward by Professor Davidson, with particular reference to the situation in Toronto vis-à-vis work with the students, the cost of Branch administration, and the necessity to promote adequate technical activities. He urged that as professional engineers the membership should be aware of its responsibilities, and be prepared to pay higher fees, if necessary, to promote the activities of the Institute.

The Treasurer, Mr. G. N. Martin, said he is in favour of Professor Davidson's objective of obtaining more funds for the Institute's work. However, he strongly recommended that this be done by raising the fees rather than by interfering with a considered separate proposal concerning free distribution of The Engineering Journal, since this proposal has many far-reaching implications.

Mr. J. H. Budden, Montreal, was in sympathy with Professor Davidson's objective, but not with the proposal regarding how this should be achieved. He thought it would tend to make the operations of the Finance Committee inflexible, and suggested that to attain the desired end, branches should instruct their councillors regarding means of raising additional fees, and how they should be expended.

Mr. C. G. Southmayd, Montreal, Chairman of the Student Policy Committee, stated that admirable work is being done by Faculty Advisors on University campuses throughout Canada. He strongly urged however, that the student fee should not revert to $4.00 per annum.

Mr. Matthews, London, and Mr. Pennock, Ottawa, spoke in favour of Professor Davidson's objective, but expressed the opinion that this should be achieved at the appropriate time by raising the fees of the Institute rather than by the method proposed.

President-Elect George McK. Dick endorsed the Treasurer's remarks, and said that if the Institute is in need of more money the best method of obtaining it is by raising the fees at the appropriate time.

The motion which had been moved by Professor A. C. Davidson, seconded by Mr. Harvey Self, was put to vote, and was defeated.

It was moved by Mr. Cassidy, seconded by Mr. Southmayd, and carried that this Annual General Meeting approve the amendment to Section 22, Journal Subscription, for subsequent submission by letter ballot to the corporate membership.

Section 28—Compounding of Fees: To agree with Section 22 as revised, to take account of the age of a member at the time of the compounding of fees, to distinguish between the fees paid by members in different localities, and to remove the stipulation that there shall be no refund of fees that have been compounded, it is proposed that Section 28 be written as follows:

"A Montreal Branch member in good standing may compound all his future annual fees by a single payment in accordance with the following schedule:

Age of Member at time of compounding	$ Amount
25	415
30	395
35	375
40	345
45	310
50	270
55	220
60	160
65	90

"All other branch residents may compound future annual fees by paying 90% of the amounts shown. Branch non-residents or non-residents may compound all future annual fees by paying 80% of the amounts shown. For intermediate years direct interpolation will apply.

"In the advent of discontinuance of membership for any cause there shall be a refund of compounded fees in the amount of 90% of the unused portion, with age 70 taken as the reference year for such calculation. Payment received for compounding of fees shall be kept in a separate fund during the period of membership of the compounder, and only the interest used for the current expenses of the Institute and the rebates to the branches."

It was moved by Mr. J. H. Budden, seconded by Mr. J. H. Fox, and carried that this Annual Meeting approves the amendment to Section 28, Compounding of Fees, for subsequent submission by letter ballot to the corporate membership.

Section 11—Affiliates: To clarify the meaning of the Section as it is presently interpreted, it is proposed that Section 11 be written as follows:

"An Affiliate shall be a person of professional status not an engineer, who collaborates in their projects or in advancing engineering knowledge."

After discussion, it was moved by Professor A. R. Edis, seconded by Dr. B. G. Ballard, and carried, that Section 11, Affiliates, be approved by this Annual General Meeting for subsequent submission by letter ballot to the corporate membership as follows:

"An Affiliate shall be a person of professional status **other than** an engineer, who collaborates with engineers in their projects or in advancing engineering knowledge."

Section 18—List of Members: To agree with present practice, which is not to issue a list each year, but on the other hand, to avoid excessive intervals between the issue of lists, it is proposed that Section 18 be written as follows:

"A list of members with the names arranged alphabetically and geographically, indicating the zones and branches, shall be sent at Council's direction to corporate members at intervals not exceeding 5 years."

After discussion, it was moved by Mr. Cassidy, seconded by Mr. C. V. Antenbring, and carried that Section 18, List of Members, be approved by the Annual General Meeting for subsequent submission by letter ballot to the corporate membership.

"A list of members with the names arranged alphabetically and geographically, indicating the zones and branches, shall be sent at Council's discretion to corporate members."

Section 45—Appointment of General Secretary, Treasurer and Committees: The functions of the Papers Committee are now performed by the Committee on Technical Operations and it is proposed that the words "the Papers Committee as described in Section 48" be deleted from Section 45, and the words "A Committee on Technical Operations of at least 6 members" be inserted in Section 45.

It was moved by Dr. B. G. Ballard, seconded by Professor W. G. Heslop, and carried unanimously that this Annual General Meeting approve the amendment to Section 45, Appointment of General Secretary, Treasurer and Committees, for subsequent submission by letter ballot to the corporate membership.

Section 48—Papers Committee: To agree with Council's decision, February 26, 1955, March 1956 and subsequently, it is proposed that Section 48 be deleted in its entirety and a new Section 48 substituted, as follows:

"The Committee on Technical Operations shall consist of representatives of the several technical divisions of the profession. It shall keep all technical activities of the Institute under constant review. It shall recommend to Council the establishment of such divisions of the Committee on Technical Operations as necessary to carry out reviews of specific fields of technical activity and also such special or standing committees of the Institute as may appear warranted by developing needs in technical areas. It shall recommend to the Publications Committee particular papers for publication. The divisions of the Committee on Technical Operations shall encourage the formation of technical sections dealing with its area of engineering in the branches, assist such technical sections in their work, and co-ordinate all activities of such technical sections in the various branches. It shall report quarterly to Council on the technical activities of the Institute."

It was moved by Mr. S. Barkwell, seconded by Mr. W. B. Pennock, and carried unanimously that this Annual Meeting approves the deletion of Section 48, Papers Committee, and the insertion in its place of the new Section 48 entitled "Committee on Technical Operations," for subsequent sumission by letter ballot to the corporate membership.

Section 75—Specifications: The Institute has not in recent years issued specifications and in view of the activities of the Canadian Standards Association and other bodies it appears unlikely to do so, and it is proposed that Section 75 be deleted.

It was moved by Mr. A. M. Toye, seconded by Mr. J. H. Budden, and carried unanimously that this Annual General Meeting approves the deletion of Section 75, Specifications, for submission by letter ballot to the membership.

45 (a) Honorary Vice-Presidents: Since there is at present no provision for the appointment of Honorary Vice-Presidents, it is proposed to authorize the President to make such appointments under Section 45 (a) as follows:

"The President may appoint a corporate member as an Honorary Vice-President for the purpose of representing the President or the Institute on a specific occasion other than at the deliberations of the Council or Committees of the Institute."

It was moved by Mr. Sillitoe, seconded by Mr. D. B. McKillop, and carried unanimously that this Annual General Meeting approve the inclusion of Section 45 (a), Honorary Vice-Presidents, in the By-Laws of the Institute, for subsequent submission by letter ballot to the corporate membership.

A motion by Mr. Harvey Self proposing an increase in membership fees of the Institute was ruled out of order. Mr. Hutchison, Toronto, gave notice of motion concerning a proposed increase in fees; and the General Secretary advised that if members desire to put forward a proposal to increase the membership fees of the EIC, the correct procedure, in accordance with the By-Laws, is for at least twenty corporate members in good standing to petition the Council for this change in By-Laws prior to October 1st.

Report of the Engineers Confederation Commission

The President stated that at the 73rd Annual General Meeting it was indicated that the Engineers Confederation Commission would be formed to prepare detailed proposals for Confederation based on a joint report of the E.I.C.'s and the C.C.P.E.'s Committees on Confederation, approved one year ago. On May 24, 1960, the Council of the Institute received the progress report from the Chairman of the Commission, Mr. John H. Fox (see page 111, June 1960 issue of The Engineering Journal).

The General Secretary read the progress report, dated May 5, 1960, of the Engineers Confederation Commission.

Mr. John H. Fox, Chairman of the Engineers Confederation Commission, was called on by the President to address the meeting, and report on the work of the Commission. Mr. Fox expressed his thanks to the Institute for this opportunity to address the Annual General Meeting on a subject close to the hearts of those present and himself.

He paid tribute to the tremendous assistance given to himself and the Commission by President J. J. Hanna, President D. Turnbull and President-Elect George McK. Dick, since the Commission was appointed. He also extended his personal thanks to every member of the Commission which he said at its meetings has had almost 100% attendance, and particularly to recognize the work of the Secretariat composed of Leo M. Nadeau of the C.C.P.E. and Garnet T. Page of the EIC.

The report presented to the 74th Annual General Meeting of the Institute was first presented to the Annual Meeting of the Canadian Council of Professional Engineers on May 11, 1960, at the same time that copies were mailed to members of the Council of The Engineering Institute of Canada. The report is published in full in the June 1960 issue of the Journal, and every effort was made therefore to ensure that the report was in the hands of both groups at about the same time.

The Commission has approached its task within the eight basic clauses and has tried to adopt a broad attitude throughout its work. The Commission is aware of the tremendous privilege which it has of participating in this work for the professional engineers of Canada, and realizes that if Confederation is achieved Canada will find itself in the position of giving world leadership in the formation of a national engineering group. Any recommendations which the Commission may make will not be restrictive but permissive, and they will not be terminal as to any date. In other words, the Commission does not envisage planning on something which will become effective on a specific date.

Mr. Fox gave a brief background of the course of negotiations from 1955, when proposals were totally unacceptable to both parties, to 1959 when the Joint Report was accepted by the EIC and the C.C.P.E., and the Engineers Confederation Commission was formed. Mr. Fox assured the Annual General Meeting that the report presented today represents some real progress in the work of the Commission. Mr. Fox then elaborated on the highlights of the report.

Mr. Fox noted that J. Graham Dale, Alberta, recently elected President of the C.C.P.E. has been replaced on the Commission by J. F. McDougall, Edmonton. Mr. Leo Roy has replaced Mr. George McK. Dick, as Vice-Chairman of the Engineers Confederation Commission, and Dean Jacques Lemieux of Sherbrooke has replaced Mr. Roy as one of the EIC representatives in the Province of Quebec. The Councils of both societies have reappointed the Chairman, Vice-Chairman, and members of the Commission for a second year, consistent with the provision of the Joint Report.

Mr. Fox stated that the final report of the Commission will be a factual presentation, and will not attempt to indicate whether or not the plans should be carried out. This problem will be referred to the membership for decision. The Commission is, however, hopeful that the answer will be obvious.

Mr. Fox stated that to-date there has been a minimum of publicity, for which he accepts responsibility with the full endorsation of the Commission. He stated that the time is now past when it is necessary to withhold publicity and that information will be available more frequently. (Applause.)

It was moved by Mr. R. B. Chandler, seconded by Mr. P. W. Gooch, and carried, that the 74th Annual General Meeting of the Engineering Institute of Canada accepts the progress report of the Engineers Confederation Commission, and records its sincere appreciation to Mr. John H. Fox, its Chairman, and the various sub-committee chairmen, for the outstanding work done todate on the preparation of a Charter that will provide an acceptable basis on which to include Confederation for Canadian engineers.

President Hanna thanked Mr. Fox for presenting his report in person to the meeting.

Honours, Medals and Prizes

The President announced that at its meeting held on April 30, 1960, the Council of the Institute unanimously voted that the following honours and medals be awarded for 1960:

Honorary Memberships
"Chosen from those who have become eminent in engineering or kindred sciences, and elected by unanimous vote of Council."
Bristow Guy Ballard,
William Percy Dobson,
John Norison Finlayson,
Richard Lankaster Hearn,
Otto Holden,

Julian C. Smith Medals (1959)
"For achievement in the development of Canada."
Clarence Decatur Howe,
Hugh Andrew Young,

Gzowski Medal
No Award.

Leonard Medal
"For papers on mining subjects."
Victor Dolmage, M.E.I.C
J. W. Stewart, M.C.I.M.

For their paper:
"Demolition of Ripple Rock"

Plummer Medal
"For papers on chemical and metallurgical subjects"
John Templeton Hugill, M.E.I.C.
For his paper:
"A large Capacity Oxygen Plant for Copper Refining"

Duggan Medal and Prize
"For the best paper dealing with the use of metals for structural and mechanical purposes"
Alan Garnett Davenport, Jr. E.I.C.
For his paper:
"The Wind-Induced Vibration of Guyed and Self-Supporting Cylindrical Columns"

Ross Medal
No Award.

Robert W. Angus Medal
"For the best paper on a mechanical engineering subject"
John James Traill, M.E.I.C.
For his paper:
"Tests of Hydraulic Turbines — An Appraisal"

Sir George Nelson Award
No eligible papers received.

Canadian Lumbermen's Association
No eligible papers received.

Junior Prizes
H. N. Ruttan
John Galbraith
Ernest Marceau
Phelps Johnson
Martin Murphy
— No recommendations

Report on Election of New Officers
The President stated that a new President, three Vice-Presidents, and the appropriate number of Councillors were elected at the December 1959 meeting of Council in accordance with the By-Laws, as follows:

(1) Extract from Minutes of February 20, 1960, meeting of Council:
"President 1960-61
60/31 On the recommendation of W. K. Gwyer, Chairman, and the majority of the 1959 Nominating Committee, the name of George McKinstry Dick, Sherbrooke, Quebec, has been nominated as the next E.I.C. President. It was:

RESOLVED unanimously that GEORGE McKINSTRY DICK, Sherbrooke, Quebec, be elected President of The Engineering Institute of Canada, for the year 1960-61, to take office at the conclusion of the 1960 Annual Meeting." ..

(2) Extract from Minutes of December 18, 1959, meeting of Council:
"Report of Nominating Committee
59/1109 It was noted that only one nomination has been received for each vacancy on the Council of the Institute for the year 1960 and that these nominations were accepted by Council on September 12, 1959, and October 17, 1959, and were published in the October, 1959, issue of The Engineering Journal for scrutiny by the membership.
59/1110 It was moved by Mr. Martin, seconded by Mr. Davis, and carried unanimously that, in accordance with Section 42 of the By-Laws, the following officers be declared elected by acclamation and asked to take office at the Annual General Meeting of the Institute to be held at the Royal Alexandra Hotel, Winnipeg, on May 25, 1960:

Vice-Presidents
One to be elected for two years
Zone "B" (Province of Ontario)
Edgar A. Cross, Toronto, Ont.
Zone "C" (Province of Quebec)
Charles Miller, Baie Comeau, Que.
Zone "D" (Atlantic Provinces)
T. C. Higginson, Saint John, N.B.
Two to be elected for three years
Montreal .... Paul G. A. Brault
R. A. Phillips

One to be elected for three years
Ottawa .... John S. Watt
Toronto .... A. C. Davidson

One to be elected for two years
Vancouver .... W. G. Heslop
Edmonton .... S. R. Sinclair
Lethbridge ...... R. D. Livingstone
Calgary .... W. G. Sharp
Saskatchewan ...... J. L. Thompson
Winnipeg .... N. S. Bubbis
Sault Ste. Marie .... W. M. Hogg
North Eastern Ont. .. (No nominee)
Huronia .... Frederic Alport
Sarnia .... J. E. Harris
Kitchener .... L. J. R. Sanders
Hamilton ... . W. A. Dawson
Niagara Peninsula .... Paul E. Buss
Peterborough .... D. A. Lamont
Cornwall .... B. T. Yates
Quebec ... . Georges Demers
Northern N.B. ...... F. W. Buckley
Moncton ... . C. L. Trenholm
North Nova Scotia .. C. V. Campbell
Halifax .... J. Douglas Kline
Cape Breton .. W. A. MacDonald"

(3) Extract from the Minutes of the April 30, 1960, meeting of Council:

"Councillors
60/157 **Baie Comeau Branch:** To complete the remainder of Mr. Charles Miller's term of office as councillor for the Baie Comeau Branch on his election to the Vice-Presidency, the Branch has nominated Mr. G. J. Lane, M.E.I.C. It was:

RESOLVED unanimously that G. J. Lane be elected councillor representing the Baie Comeau Branch to take office at the 1960 Annual Meeting and to complete the remainder of Mr. Miller's term of office, until May 1961.

60/158 **Saint John Branch:** To complete the remainder of Mr. T. C. Higginson's term of office as councillor for the Saint John Branch on his election to the Vice-Presidency, the Branch has nominated Mr. J. J. Donahue, M.E.I.C. It was:

RESOLVED unanimously that J. J. Donahue be elected councillor representing the Saint John Branch to take office at the 1960 Annual Meeting and to complete the remainder of Mr. Higginson's term of office, until May 1961."

President-Elect George McK. Dick was introduced to the meeting. (Applause.)

Other Business
The President read a telegram from the President of the Royal Architectural Institute of Canada which extended good wishes to the Institute on its 74th Annual Meeting.

It was moved by Dean H. G. Conn, seconded by Past-President V. A. McKillop, and carried with acclamation that the 74th Annual General Meeting of the Engineering Institute of Canada congratulates Past-President J. B. Stirling, one of the Institute's most respected senior members, on his appointment as Chancellor of Queen's University. The meeting recognized this appointment as an honour, not only to Dr. Stirling, but to the engineering profession and the Institute.

It was moved by Past-President V. A. McKillop, seconded by Past-President James A. Vance, and carried unanimously that a message of encouragement and sympathy be sent to Mrs. L. F. Grant, wife of Past-President L. F. Grant, in her illness. Colonel L. F. Grant stated that he wished to express to his friends and associates his deep appreciation of the expression of sympathy accorded.

Vote of Thanks
It was moved by Past-President James A. Vance, seconded by Past-President L. F. Grant, and carried with acclamation that a hearty vote of thanks be accorded to the retiring President, Vice-Presidents and members of Council in appreciation of the work they have done for the Institute during the past year.

Motion of Adjournment
It was moved by Mr. J. H. Budden, seconded by J. B. Angel, and carried that the 74th Annual General Meeting of The Engineering Institute of Canada be adjourned.

The meeting adjourned at 12.00 noon.

J. J. Hanna,
President.

Garnet T. Page,
General Secretary.

The Engineering Institute of Canada,
2050 Mansfield Street,
Montreal 2, Quebec.

COMMONWEALTH CO-OPERATION

(Continued from page 88)

Division or Committee.

4. Where a Branch of the E.I.C. has appropriate specialist Engineering Sections, members of sister societies resident in the area are invited to participate in local activities on the same basis as the E.I.C. members in those Sections, and are to be represented in each case, where warranted and justified by numbers in that speciality and as agreed by the societies concerned, by a member appointed to the appropriate Section executive, the appointment to be made by the sister society. Members so appointed are to become full voting members of the Section Executive.

5. Where a Branch of the E.I.C. has appropriate Engineering discussion groups, members of sister societies resident in the area are invited to participate in the activities of the Groups of their interest on the same basis as E.I.C. members.

6. Where a Branch of the E.I.C. has neither an appropriate specialist Engineering Section nor an appropriate specialist Engineering discussion group, members of sister societies resident in that area are invited to participate in Branch activities on the same basis as E.I.C. members.

7. Such members of other societies resident in Canada and wishing to participate in the activities of an E.I.C. Branch will be billed by the E.I.C. Headquarters in the amount of $3.00 per annum to cover the cost of meeting facilities, mailing notices, etc. They shall be eligible to receive the Engineering Journal at the same rate as E.I.C. members, and the Transactions of the E.I.C. at a cost of $1.00 per annum. Where reciprocity is accorded by the other Commonwealth society, members of the E.I.C. resident in that country will be billed by that society for out-of-pocket service costs plus additional charge at member rates for the publications of the society.

8. It is the hope of the Council of the E.I.C. that members taking advantage of these arrangements will ultimately become members of the E.I.C.

Branch Chairman,
Branch Secretaries,
The Engineering Institute of Canada.

Gentlemen:

Enclosed is a copy of a letter and attachment which we are sending to all members of the three Institutions named, in Canada. Enclosed also is a copy of the Memorandum setting forth the basis for E.I.C. co-operation with these members, as approved by the Councils of the four societies concerned.

From the above you will note that E.I.C. Headquarters is now writing to each Institution member in Canada, and is sending the "Journal" to each of them. They are also being sent a statement requesting the sum of $3.00 per year, if they desire to take advantage of this agreement. We will also write to them regarding their participation in the overall technical activities of the Institute, so that items 1, 2 and 3 may be carried out.

A great deal of responsibility for the success of this plan rests with each Branch of the Institute. Item 1 states that Branches of the E.I.C. are to be encouraged to establish specialist engineering discussion groups wherever justified by numbers and interest. The importance of this aspect of the plan cannot be over emphasized; and the Committee on Technical Operations and the Headquarters' staff will be glad to advise and assist any Branch which may desire assistance in this area of activity.

The responsibility for the effective implementation of items 4, 5 and 6 rests completely with the Branches, and the co-operation of all Branch Executives will be appreciated. To clear up any possible misunderstanding, the intent of giving the one Institution representative a vote in the executive of the Branch Technical Section is to permit participation and representaton of the group of the Institution members which he represents in the work of the Technical Section. It is not intended that these voting privileges be extended at the level of the Branch Executive itself.

The administrative action required by item 7 is being taken by E.I.C. Headquarters. We are sending each Branch Secretary the following information:

(a) A list of all members of the three Institutions in each Branch area.

(b) The names of those who remit the $3.00 annual fee.

(c) The sum of $2.00 for each of (b) above, to be used by the Branch in serving these members. The remaining $1.00 is to cover Headquarters administrative costs.

Item 8 is self-explanatory. It is hoped that the local and national activities of the E.I.C. will encourage the Institution members ultimately to become full members of the E.I.C.

Council hopes that each Branch will give this scheme its whole-hearted support, for the improvement of the Institute's technical activities and services to the profession of engineering in Canada.

Yours very truly,
Garnet T. Page, M.E.I.C.,
General Secretary.

Another Victory for General McNaughton

General the Hon. A. G. L. McNaughton, Hon. M.E.I.C. has a history of achievement for the Canadian people. Recently, a tribute was paid to him in an Ottawa datelined editorial which appeared in the Winnipeg Free Press. The editorial entitled "Victory for General McNaughton", called him "the real hero of the Columbia negotiations".

Following are excerpts from the editorial:

"It is a notable event when a public man, single-handedly, scores the greatest triumph in his career. This is especially so when the fruits of the triumph go not at all to himself—save in credit—but entirely to his country.

"General the Hon. A. G. L. McNaughton, age 73, chairman of the Canadian Section of the International Joint Commission . . . has had one of the most unusual careers in Canadian military and public life. He fought in many real battles in World War I. He prepared for but never fought in any of the battles of World War II. He engaged in and was overwhelmingly defeated in a short political engagement in 1944-45.

"But of all the varied contests and strivings of a long life spent mostly at what might be termed the command posts of military or public affairs the battle of Columbia River marks the greatest achievement in General McNaughton's career.

"The writer followed the Columbia River negotiations very closely, from 1950 until the change in government in 1957. These were the crucial years. And it may be said, without peril of contradiction, that General McNaughton in this matter, took on a lost cause and confronted his opposite numbers on the U.S. section of the International Joint Commission. He had no cards in his hand. The St. Laurent government was but lukewarm in supporting him. In reality he fought alone."

The editorial outlined the practical problems involved in the negotiations and the United States philosophy concerning power development particularly in the Western United States. The Pacific states were clamouring for the 2,600,000 h.p. available from the Columbia River. They faced a power shortage and the United States of course was eager to pay for the storage facilities in Canada, and powerful interests in Canada were favorable to this U.S. ambition.

"General McNaughton announced a completely revolutionary policy when he insisted that Canada should build and operate any storage dams in Canada and must receive, free of charge, 50% of all downstream benefits. One half the power obtained in the U.S. in this way must be returned to Canada.

"If General McNaughton had exploded hydrogen bombs at Washington, D.C. and in the Pacific states, the shock would scarcely have been greater."

Through extremely strenuous and imaginative negotiations during which the United States had four chairmen of their section of the Commission, General McNaughton achieved 90% of his objective.

"General McNaughton, although his own government was plainly shocked . . . put his engineers to work and was able to announce that, failing a satisfactory settlement with the U.S., Canada would divert the flood water of the Columbia out of this river and ino the Thompson River. Thence it would flow through the Fraser to the sea—all in Canada. This would mean that Canada would get all the power from the flood water and the U.S. none."

With no real support from either the Federal or the British Columbia governments General McNaughton made his point and saw negotiations concluded in what was a signal victory for Canada.

"Single-handed, with no help except from a few senior officials and his own devoted staff, General McNaughton made it possible for the Canadian government to establish the principal that Canada is entitled to receive one half of the downstream benefits of water storage in this country. For unexplained reasons, he was allowed to play no part in the final negotiations."

"General McNaughton is entitled to be acclaimed, without qualification, as a man who refused to admit defeat, refused to be turned aside by the discouragement and by lack of support, and who, in the end, achieved the seemingly impossible."

October Council Meeting

Council of the Institute met in Sherbrooke, Que., on Friday evening, Oct. 28, and Saturday, Oct. 29. President Dick presided. The following is a summary report of the meeting.

Annual and Regional Meetings

The General Secretary reported on his visit to the Vancouver Branch Sept. 27-28 to initiate arrangements and local planning for the 1961 Annual General Meeting. A series of extremely useful meetings was held, and local planning is well advanced. Chairman and Vice-Chairman of the 1961 AGM, respectively, are Dean D. M. Myers and Professor W. G. Heslop.

Other appointments include: F. M. Cazalet, Secretary; C. Peter Jones, Program Chairman; John Davis, Hotel Arrangements Chairman; A. D. Cronk, Public Relations Chairman; and H. R. Wright, Banquet and Dance Chairman.

Future Annual General Meetings

Council approved the following schedule of future Annual General Meetings:

1961 Vancouver May 31-June 2 Hotel Vancouver
1962 Montreal June 13-June 15 Queen Elizabeth
1963 Quebec May 22-May 24 Chateau Frontenac
1964 Banff May 27-May 29 Banff Springs
1965 Toronto May 26-May 28 Royal York
1966 Winnipeg May 25-May 27 Royal Alexandra
1967 Montreal May 31-June 2 Queen Elizabeth
1968 Halifax — —

Committee on Membership

On the recommendations of S. B. Cassidy, Chairman of the Committee on Membership the following were appointed members of the Committee:

R. Bing Wo, Regina
Colonel W. A. Capelle, Ottawa
Gaetan Cote, Sherbrooke
Professor J. W. Dolphin, Kingston
C. Fisher, Winnipeg
Yvon Hardy, Montreal
C. Peter Jones, Vancouver
R. J. Kane, Montreal
Miss Elsie MacGill, Toronto
Professor G. F. Vail, Halifax

Ex. Officio:

Hugh C. Brown
The President
The Vice-President

Mr. Cassidy said the Committee will hold its first meeting concurrently with that of the Executive Committee in Toronto, Nov. 19, and that Branch Chairmen, Secretaries, and Chairmen of Branch Membership Committees located near Toronto were invited to attend.

He urged every member of the Institute to be prepared to participate in the work of the Committee on Membership. The President said he anticipates the Committee will embark on an intensive campaign and that all Councillors and Branch Officers can expect to be asked to work closely with the Committee.

Dr. B. G. Ballard, Chairman of the Committee on Technical Operations, said the CTO is aware of its responsibility to assist the Committee on Membership particularly in respect to younger members. Dr. Ballard suggested that forums be held at the Branch level at which prominent engineers discuss what is expected of engineers with university students. It was agreed that this suggestion be referred to the Committee on Membership.

Technical Operations

Council discussed the part the CTO should play in assisting with the technical programs of regional technical conferences. It was resolved that Council entrust responsibility for co-ordination of regional technical conferences and approval of requests for holding such meetings to the Committee on Technical Operations.

It was further resolved that the resolution adopted above be referred to the By-Laws Committee for examination, tying in with Section 54 of the By-Laws, and subsequent presentation with other by-law changes at the appropriate time.

Sub-Committee on Water Pollution

A. L. Van Luven of Montreal is chairman of this Sub-Committee established by the Committee on Technical Operations. The Sub-Committee is to study all phases of the use, conservation and pollution of water resources in Canada.

It will become familiar with work now being done by many organizations in this field, and solicit and analyze views of all Canadian organizations concerned with water pollution. Later, if justified, it will suggest a program for action by governments and industry. Reaction of all interested organizations to this suggested program will be ascertained.

It will make a final or interim report to the E.I.C. on these matters with recommendations preferably no later than the 1961 Annual General Meeting. With approval of Council this report will be sent to the Prime Minister and to provincial premiers. This will provide an objective, scientific and unbiased analysis of the use, conservation and pollution of water resources in Canada which can be used by the federal and provincial governments as a comparison with their own work.

Branch Operations

President Dick, Past-President J. J. Hanna, Vice-Presidents Lawton and E. A. Cross spoke in firm support of a proposal by the General Secretary that a Committee on Branch Operations be established. The consensus was that the three vital and related activities of the Institute are: the rendering of maximum assistance to Branches, the work of the Committee on Technical Operations, and the work of the Committee on Membership.

The objective of such a committee would be primarily to provide encouragement and assistance to Branches when required. Included among the methods by which this could be accomplished are the Branch Officers' Conference, forums at annual general meetings, and the appointment of a CTO representative at each Branch to help integrate and promote the technical program of the Branch.

It was resolved that a Committee on Branch Operations be established, with the object of studying and recommending regarding Branch operations, and providing a focus of activity for rendering maximum assistance to Branches.

Royal Commission on Publications

The Institute has been invited to prepare a submission to this Commission. The Commission is to inquire into the position and prospects of Canadian magazines with special consideration being given to competition from similar publications which are edited largely or entirely outside Canada, or are largely or entirely foreign in content.

The General Secretary was authorized to prepare a submission to this Commission, subject to approval of the submission by the President, the Chairman of the Finance Committee, and the Chairman of the Publications Committee.

Royal Commission on Government Administration

A Royal Commission was established recently to make a thorough study of the operations of the Federal Government. The President reported that he had instructed the General Secretary to recommend concerning a special committee to prepare a brief for presentation by the President to this Commission.

Council ratified the President's action and agreed that a special committee should be appointed.

Senate Special Committee on Manpower and Employment

The E.I.C. has been invited to prepare a submission to this Special Committee.

Council resolved that a committee be appointed to prepare a presentation to be submitted to the Committee by the President.

Tariff Board Submission

In June, 1946, the Federal Government removed the tariff on several classifications of engineers' plans. The Institute protested this action, and in January, 1951, the Tariff Board held a hearing to consider the method of valuing plans for customs purposes and to hear arguments for or against the 1946 action. The Institute asked for the restoration of a tariff in certain cases, and a change in the basis of evaluation. Two tariff items now are to be studied again by the Tariff Board.

The General Secretary made certain proposals which might be considered a basis for discussion of an Institute brief to the Tariff Board.

After discussion it was resolved that the General Secretary's statement of proposals and background be communicated to all members of Council. Councillors are to discuss this at the Branch level, and to submit comments and suggestions to a Special Committee which Council authorized the President to appoint to prepare a brief for submission by the President to the Tariff Board.

Confederation

During the summer, several committees of the Engineers Confederation Commission were extremely active and the General Secretary has devoted a major portion of his time to the work of these committees.

Dr. J. Hoogstraten recently resigned as E.I.C. representative for Nova Scotia to the Engineers Confederation Commission, because he moved to Manitoba. Council ratified the nomination by E.I.C. Councillors in Nova Scotia of G. F. Vail as Dr. Hoogstraten's successor.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on October 29, 1960.

Member: H. B. Baardman, Montreal; M. E. Belgrave, British Guiana; J. C. Campbell, Sydney, N.S.; D. R. Cole, Edmonton; J. D. Coughlan, Montreal; J. J. Danic, Sarnia; L. D. Dougan, Sarnia; G. I. H. Drewett, Edmonton; R. H. Edwards, Longueuil; C. K. Fong, Hong Kong; D. F. Griffiths, Trail; J. V. Johnson, Yukon; P. B. Lawrence, Toronto; T. C. Morgan, Ottawa; R. F. Norman, Toronto; F. B. Odasz, Calgary; J. D. Palmer, Kingston; R. S. Phillips, Peterborough; W. M. Prentice, Toronto; R. M. Richardson, Calgary; P. E. Riverin, Montreal; P. A. Schaerer, Ottawa; S. Shivdasani, Montreal; C. G. Smallridge, Montreal; W. J. Swarbrick, Vancouver; H. H. Warsch, Ottawa; A. H. Yarberry, Montreal.

Junior: C. N. Armstrong, Kitimat; A. Cowley, England; I. W. Geba, Montreal; B. J. Maunder, Port Coquitlam; J. L. McDougall, Velder Crossing; R. M. Savoie, Drummondville; R. E. Walker, Prince Rupert.

Junior to Member: A. Ainley, Toronto; E. R. Acton, Brockville; A. Alexander, St. Catharines; D. G. S. Anderson, Waterloo, Ont.; J. Anderson, Toronto; D. B. Ashenden, Brockville; S. M. Bancroft, Ottawa; D. J. Bazett, Toronto; G. Bird, Toronto; J. R. Bisaillon, Quebec; D. D. Brouse, Toronto; W. A. Brown, Scarborough; J. G. Celmins, Toronto; W. O. Chisholm, Toronto; W. B. Chong, Toronto; E. K. Christian, Toronto; R. H. Clendining, Toronto; W. H. Correll, Toronto; J. F. M. Craig, Nobel; R. M. Currie, Oakville; K. I. Fletcher, Sault Ste. Marie; L. J. Foord, Peterborough; R. W. Goldie, Montreal; A. G. Hamilton, Port Credit; C. Hebert, Oshawa; J. C. Huot, Quebec; S. R. Johnson, Toronto; J. L. Kendry, Asbestos; F. B. Kraft, Preston; W. A. H. McCorquodale, Syracuse, N.Y.; I. B. Miller, Toronto; H. R. M. Murray, Yale, B.C.; R. J. Noonan, Winnipeg; R. O. Olsen, Buckingham; W. P. O'Malley, Montreal; J. A. Pihlainen, Ottawa; G. W. Piper, London, Ont.; D. G. Pyper, Toronto; D. A. Ridler, Toronto; J. T. Rogers, Peterborough; P. A. Ross-Ross, Chalk River; J. W. Saunders, Montreal; H. N. Shoji, Toronto; G. A. Sicotte, Montreal; D. S. Simons, Winnipeg; W. B. Sproule, Sault Ste. Marie; H. M. Steckley, Toronto; J. J. Stefaniszyn, Montreal; J. M. Sterling, Toronto; L. W. Stock, Toronto; W. D. Tanner, St. Catharines; E. Turcot, Montreal; T. G. Tustin, Montreal; J. L. Vachon, Ottawa; E. C. Walton, Toronto; A. A. Williams, Montreal; B. A. Wilson, California; A. Woinowsky-Krieger, Quebec; P. Yachimec, Toronto; K. H. Yeo, Hamilton.

Student to Junior: J. L. Coughlan, Montreal; L. E. Wells, Perth.

STUDENTS ADMITTED

McGill University: I. A. Cermak, A. H. Cohen, A. Giannetti, R. G. Haack, C. W. L. Horn, V. K. Jyoti, I. Lamoureux, P. Linke, A. P. M. Lyell, J. G. Masstrom, S. M. Newman, B. Ornstein, P. A. Osho, G. M. Peck, G. F. Reynard, J. K. Siebrasse, T. H. F. Tan, T. Tarasofsky, N. Theodore, J. C. Vanagas, T. D. Wyglinski, G. A. Yane.

University of Toronto: F. J. Boyer, A. Buttemer, G. D. Caldwell, W. R. Campbell, J. Citron, G. T. Coffey, D. Currey, D. H. Dignan, G. J. Fournier, C. A. Fuller, K. C. Galbraith, J. A. Gibson, S. M. Glogowski, D. Hilson, M. J. Huggins, G. V. M. Jacquemain, P. J. Jaunzems, O. M. Kaustinen, F. J. Keenan, D. J. Lamb, M. S. C. Law, D. McHardy, R. E. Pearson, L. J. Regimbal, P. J. Rolfe, I. R. Russell, H. B. Snell, R. H. Temple, W. S. Wolfe, G. J. Woolgar.

Nova Scotia Technical College: D. T. Campbell, C. B. Day, G. M. Dlugosch, P. J. Driscoll, J. V. Gavin, F. A. Gervais, R. A. Gould, E. B. Hatfield, W. R. Hicks, J. R. Kane, C. R. King, J. B. Lavigne, D. P. MacAulay, D. J. Major, E. R. Trask.

Loyola College: B. W. A. Abela, S. J. Abela, F. K. Aitken, F. H. Allen, R. Allen, R. L. Bayly, R. J. Bernard, J. E. P. Bilodeau, D. J. F. Bryden, J. W. Bush, P. R. Byers, J. E. Cain, G. K. Carrall, B. Castongway, T. S. Coughlin, C. R. Cooper, R. A. Deegan, P. De Grace, J. P. G. Desrosiers, F. Diamente, A. B. Edwards, V. M. Espaillat, M. J. Feeney, D. E. Fisher, D. H. Forbes, J. R. Fortin, M. Frappier, P. F. Gaboury, J. A. Galle, P. R. Grant, J. R. Greene, G. L. Harold, R. A. Harrison, J. J. G. Hemens, K. L. W. Hui, D. W. S. Kay, A. E. Kennedy, R. J. Kind, J. S. K. Kwan, G. Laberge, E. A. D. F. Lamoureux, D. C. L. Louie, J. E. J. G. Lapierre, E. C. S. Lau, S. Y. S. Lau, B. W. Lawson, J. Leclerc, M. B. Ledwidge, S. Legedza, A. J. Lemay, W. W. Leus, M. Levasseur, L. J. Liebich, L. Mahoney, F. J. McCaughey, M. McAughey, K. J. McGuire, L. T. McKinnon, T. Molloy, G. P. Morrison, A. J. O'Doherty, J. H. O'Donnell, A. J. O'Grady, F. J. O'Hara, W. R. Oulton, R. Paci, P. Peduhha, K. J. E. Peter, M. Przystal, J. Resther, O. Roy, A. G. Russo, L. G. Sablauskas, J. Scheigetz, D. P. Scipio del Campo, L. Sheehan, A. P. Smeaton, E. Smilgis, R. B. L. Stoddart, M. F. Sullivan, R. A. P. Sweeney, J. M. Thibault, G. J. Tokar, P. Y. Tong, J. Trifilette, J. W. T. Tsang, F. Turco, R. Valiquette, A. J. Viney, R. A. Walsh, R. J. Wiseman, P. Wong, S. S. A. Wong, D. Zee.

Sir George Williams University: V. Bartfay, N. J. Bertalanits, J. Bourdeau, R. D. Bourke, A. C. F. Chau, D. C. Chong, B. Cytrynbaum, P. T. Dalamangas, A. R. Degruchy, J. G. Descoteaux, P. N. Foster, S. L. Garelick, E. S. Hewitt, W. Huculak, S. T. Le Bedis, E. Y. M. Lee, J. N. Malhotra, J. M. N. Martin, F. Masters, P. Ratki, I. D. Robertson, M. Talerman, J. G. Thistle.

Dalhousie University: J. F. Adams, B. W. Aikman, B. Balbirsingh, G. O. Bishop, A. R. Blenkhorn, L. G. Currie, A. B. Ferguson, A. A. Ferguson, C. A. Hamer, D. S. Hopkins, R. L. Howe, A. Leung, E. A. MacAulay, D. R. MacDonald, G. W. MacDonald, I. F. Macdonald, S. W. March, J. L. McLean, A. G. Roop, G. L. Trider.

Carleton University: R. F. Alexander, R. M. Bayley, J. A. Dolan, J. M. Hamilton, G. E. Kirby, K. A. H. Lythall, F. D. McAllum, M. H. Quast, R. W. Smith, L. Thelwell, W. E. Wilson.

University of Western Ontario: J. G. Gammage, G. J. Kopp, J. A. Lyons, E. A. Marriage, R. J. Morris, J. R. Nancekivell, J. S. Scherer, M. W. Stewart.

McMaster University: J. J. Brokloff, I. A. Hollis.

University of Alberta: D. E. Laukner.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective October 29, 1960.

ALBERTA

Member: M. J. Baron.
Junior to Member: A. W. Peterson, S. A. Rokosh.

SASKATCHEWAN

Members: P. Graystone, B. V. Loginoff.
Student: E. H. J. Rotelick.

NOVA SCOTIA

Members: M. R. Evans, C. F. Pearce, L. M. Shaer.
Junior to Member: I. C. MacInnes.

MANITOBA

Member: A. F. Klymchuk.

University Registration

A general increase has been noted in this year's university engineering enrolment as tabulated (on the following pages) by the Institute from information obtained directly from registrars. This tabulation now is an annual Journal service to its readers.

Several highlights of this year's situation, as revealed by the E.I.C.'s survey, are:

Total enrolment in Canadian engineering courses now stands at 14,940, an increase of 465 from last year;

The engineering freshmen number 4,461 in the autumn of 1960, compared with 4,122 last year;

The estimated number of 1961 graduates, making no allowance for wastage during the year, is 2,651. This is an increase of 410 over the previous year.

Civil, electrical, and mechanical engineering remain the most popular. The following is a list of the 1961 graduates, with the previous year's estimates in brackets. Civil 779 (644), Electrical 644 (513), Mechanical 508 (438).

New colleges giving recognized engineering courses are still being added to the list. On this occasion we welcome Loyola, Montreal, and Laurentian, Sudbury.

Readers will be able to make further detailed observations by study of the tables. However, if any question should arise, E.I.C. Headquarters will gladly try to answer them.

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Total
Memorial	1st	55	....	....	....	....	....	....	....	....	....	....	....	....	55
	2nd	48	....	....	....	....	....	....	....	....	....	....	....	....	48
	3rd	65	....	....	....	....	....	....	....	....	....	....	....	....	65
Total............		168	....	....	....	....	....	....	....	....	....	....	....	....	168
Dalhousie	1st	81	....	....	....	....	....	....	....	....	....	....	9	....	90
	2nd	95	....	....	....	....	....	....	....	....	....	....	6	....	101
	3rd	29	....	....	....	....	....	....	....	....	....	....	6	....	35
	4th	....	....	....	....	....	....	....	....	....	....	....	4	....	4
Total............		205	....	....	....	....	....	....	....	....	....	....	25	....	230
St. Mary's	1st	52	....	....	....	....	....	....	....	....	....	....	....	....	52
	2nd	23	....	....	....	....	....	....	....	....	....	....	....	....	23
	3rd	39	....	....	....	....	....	....	....	....	....	....	....	....	39
Total............		114	....	....	....	....	....	....	....	....	....	....	....	....	114
St. Francis Xavier	1st	80	....	....	....	....	....	....	....	....	....	....	....	....	80
	2nd	66	....	....	....	....	....	....	....	....	....	....	....	....	66
	3rd	85	....	....	....	....	....	....	....	....	....	....	....	....	85
Total............		231	....	....	....	....	....	....	....	....	....	....	....	....	231
N.S. Technical College	4th	....	....	....	17	53	47	....	....	38	9	3	....	....	167
	5th	....	....	....	13	61	39	....	....	24	2	3	....	....	142
Total............		....	....	....	30	114	86	....	....	62	11	6	....	....	309
Acadia	1st	59	....	....	....	....	....	....	....	....	....	....	....	....	59
	2nd	35	....	....	....	....	....	....	....	....	....	....	....	....	35
	3rd	35	....	....	....	....	....	....	....	....	....	....	....	....	35
Total............		129	....	....	....	....	....	....	....	....	....	....	....	....	129
Mount Allison	1st	65	....	....	....	....	....	....	....	....	....	....	....	....	65
	2nd	48	....	....	....	....	....	....	....	....	....	....	....	....	48
	3rd	46	....	....	....	....	....	....	....	....	....	....	....	....	46
Total............		159	....	....	....	....	....	....	....	....	....	....	....	....	159
New Brunswick	1st	....	....	....	15	70	35	....	....	27	....	1	....	5	153
	2nd	....	....	....	14	66	58	....	....	27	....	2	....	....	167
	3rd	....	....	....	8	45	25	....	....	28	....	....	....	....	106
	4th	....	....	....	6	53	37	....	....	21	....	....	....	....	117
	5th	....	....	....	....	57	34	....	....	22	....	....	....	....	113
Total............		....	....	....	43	291	189	....	....	125	....	3	....	5	656
St. Joseph's	1st	43	....	....	....	....	....	....	....	....	....	....	....	....	43
	2nd	25	....	....	....	....	....	....	....	....	....	....	....	....	25
	3rd	14	....	....	....	....	....	....	....	....	....	....	....	....	14
Total............		82	....	....	....	....	....	....	....	....	....	....	....	....	82
Laval	1st	221	....	....	....	....	....	....	....	....	....	....	....	....	221
	2nd	247	....	....	....	....	....	....	....	....	....	....	....	....	247
	3rd	....	....	....	11	52	32	....	2	26	7	2	8	....	140
	4th	....	....	....	5	61	22	....	3	20	2	4	6	....	123
	5th	....	....	....	5	54	29	....	3	17	7	5	5	....	125
Total............		468	....	....	21	167	83	....	8	63	16	11	19	....	856
Ecole Polytechnique	1st	250	....	....	....	....	....	....	....	....	....	....	....	....	250
	2nd	341	....	....	....	....	....	....	....	....	....	....	....	....	341
	3rd	270	....	....	....	....	....	....	....	....	....	....	....	....	270
	4th	....	....	....	12	104	51	....	2	46	13	24	17	....	269
	5th	....	....	....	7	97	48	....	6	36	7	9	21	....	231
Total............		861	....	....	19	201	99	....	8	82	20	33	38	....	1,361

REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Total
McGill	1st	285	....	....	....	....	....	....	....	....	....	....	....	....	285
	2nd	247	....	....	....	....	....	....	....	....	....	....	....	....	247
	3rd	....	....	....	21	36	78	....	....	41	6	3	11	....	196
	4th	....	....	....	26	76	109	....	....	66	9	1	7	....	294
	5th	....	....	....	21	69	96	....	....	53	10	7	6	....	262
Total............		532	....	....	68	181	283	....	....	160	25	11	24	....	1,284
Sir George Williams	1st	130	....	....	....	....	....	....	....	....	....	....	....	....	130
	2nd	75	....	....	....	....	....	....	....	....	....	....	....	....	75
	3rd	51	....	....	....	....	....	....	....	....	....	....	....	....	51
Total............		256	....	....	....	....	....	....	....	....	....	....	....	....	256
Loyola	1st	89	....	....	....	....	....	....	....	....	....	....	....	....	89
	2nd	60	....	....	....	....	....	....	....	....	....	....	....	....	60
	3rd	....	....	....	1	19	6	....	....	10	....	2	5	....	43
Total............		149	....	....	1	19	6	....	....	10	....	2	5	....	192
Sherbrooke	1st	75	....	....	....	....	....	....	....	....	....	....	....	....	75
	2nd	42	....	....	....	....	....	....	....	....	....	....	....	....	42
	3rd	34	....	....	....	....	....	....	....	....	....	....	....	....	34
	4th	....	....	....	....	17	13	....	....	10	....	....	....	....	40
	5th	....	....	....	....	17	9	....	....	3	....	....	....	....	29
Total............		151	....	....	....	34	22	....	....	13	....	....	....	....	220
Ottawa	1st	66	....	....	7	27	4	....	....	....	....	....	....	....	104
	2nd	28	....	....	8	32	14	....	....	....	....	....	....	....	82
	3rd	5	....	....	8	14	18	....	....	....	....	....	....	....	45
	4th	2	....	....	4	....	14	....	....	....	....	....	....	....	20
	5th	....	....	....	6	....	5	....	....	....	....	....	....	....	11
Total............		101	....	....	33	73	55	....	....	....	....	....	....	....	262
Carleton	1st	39	....	....	....	....	....	....	....	....	....	....	....	....	39
	2nd	30	....	....	....	....	....	....	....	....	....	....	....	....	30
	3rd	30	....	....	....	....	....	....	....	....	....	....	....	....	30
	4th	19	....	....	....	....	....	....	....	....	....	....	....	....	19
Total............		118	....	....	....	....	....	....	....	....	....	....	....	....	118
Queen's	1st	232	....	....	....	....	....	....	....	....	....	....	....	....	232
	2nd	....	....	....	21	51	42	....	14	39	12	12	17	....	208
	3rd	....	....	....	36	37	38	....	11	43	7	4	32	....	208
	4th	....	....	....	48	40	43	....	11	32	7	10	25	....	216
Total............		232	....	....	105	128	123	....	36	114	26	26	74	....	864
Toronto	1st	....	....	....	82	68	77	20	12	53	11	5	88	....	416
	2nd	....	....	....	66	64	86	25	8	77	12	4	83	....	425
	3rd	....	....	....	54	54	71	37	11	69	10	10	92	....	408
	4th	....	....	....	50	90	81	26	13	83	15	15	79	....	452
Total............		....	....	....	252	276	315	108	44	282	48	34	342	....	1,701
McMaster	1st	78	....	....	....	....	....	....	....	....	....	....	....	....	78
	2nd	....	....	....	12	9	11	....	....	10	4	....	6	....	52
	3rd	....	....	....	7	....	14	....	....	9	1	....	4	....	35
	4th	....	....	....	5	....	8	....	....	8	....	....	4	....	25
Total............		78	....	....	24	9	33	....	....	27	5	....	14	....	190
Ontario Agricultural College	2nd	33	....	....	....	....	....	....	....	....	....	....	....	....	33
	3rd	....	....	....	....	19	....	....	....	8	....	....	....	....	27
	4th	....	....	....	....	12	....	....	....	9	....	....	....	....	21
Total............		33	....	....	....	31	....	....	....	17	....	....	....	....	81

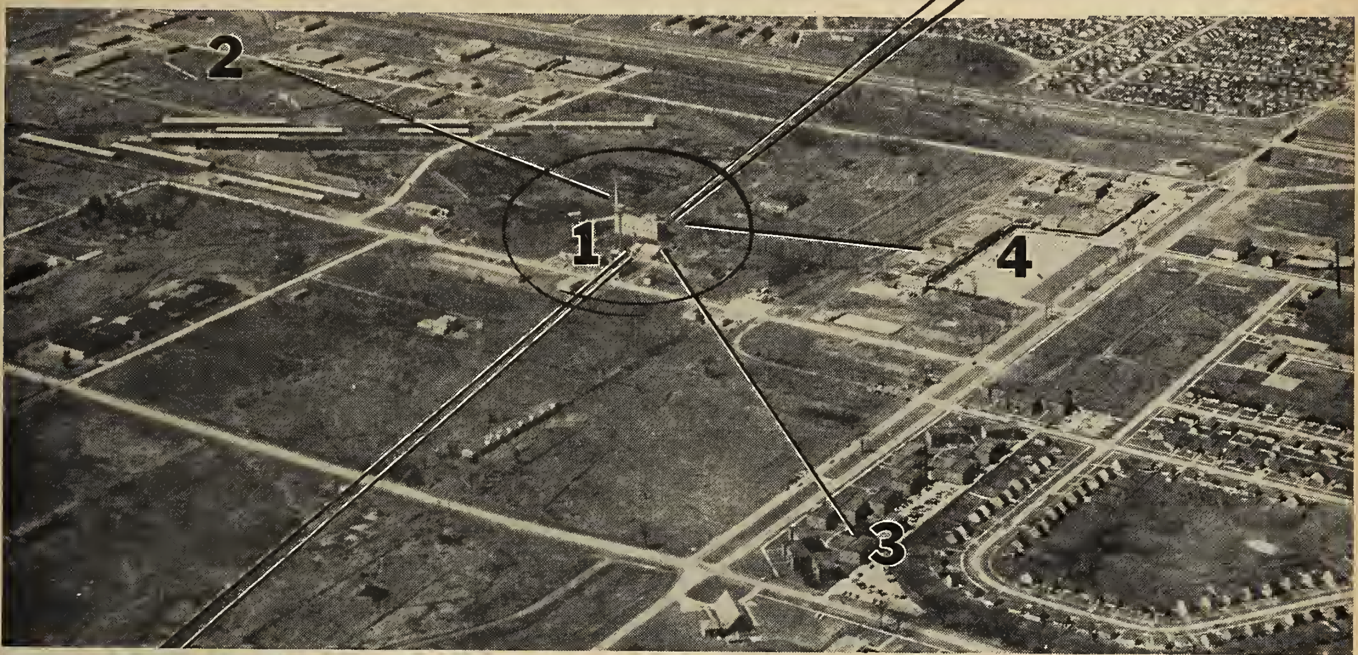
REGISTRATION IN ENGINEERING AT CANADIAN UNIVERSITIES

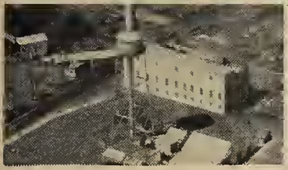
University	Year	General Course	Agricultural Engineering	Petroleum Engineering	Chemical Engineering	Civil Engineering	Electrical Engineering	Industrial Engineering	Geology and Mineralogy Engineering	Mechanical Engineering	Metallurgical Engineering	Mining Engineering	Engineering Physics	Surveying Engineering	Total
Waterloo	1st	219	....	....	....	....	....	....	....	....	....	....	....	....	219
	2nd	....	....	....	28	29	43	....	....	40	....	....	21	....	161
	3rd	....	....	....	22	47	36	....	....	35	....	....	15	....	155
	4th	....	....	....	14	21	6	....	....	15	....	....	15	....	71
Total		219	....	....	64	97	85	....	....	90	....	....	51	....	606
Western Ontario	1st	93	....	....	....	....	....	....	....	....	....	....	....	....	93
	2nd	43	....	....	....	....	....	....	....	....	....	....	....	....	43
	3rd	....	....	....	3	7	6	....	....	8	....	....	....	....	24
	4th	....	....	....	4	7	6	....	....	4	....	....	....	....	21
Total		136	....	....	7	14	12	....	....	12	....	....	....	....	181
Assumption	1st	52	....	....	....	....	....	....	....	....	....	....	....	....	52
	2nd	....	....	....	5	13	17	....	....	6	....	....	....	....	41
	3rd	....	....	....	4	18	11	....	....	1	....	....	1	....	35
	4th	....	....	....	5	8	8	....	....	4	....	....	....	....	25
Total		52	....	....	14	39	36	....	....	11	....	....	1	....	153
Laurentian	1st	13	....	....	....	....	....	....	....	....	....	....	....	....	13
Total		13	....	....	....	....	....	....	....	....	....	....	....	....	13
Manitoba	1st	214	....	....	....	....	....	....	....	....	....	....	....	....	214
	2nd	149	....	....	....	....	....	....	1	....	....	....	8	....	158
	3rd	....	....	....	....	56	41	....	2	33	....	....	5	....	137
	4th	....	....	....	....	65	48	....	3	41	....	....	6	....	163
Total		363	....	....	....	121	89	....	6	74	....	....	19	....	672
Saskatchewan	1st	347	....	....	....	....	....	....	....	....	....	....	....	....	347
	2nd	239	....	....	....	....	....	....	....	....	....	....	....	....	239
	3rd	....	19	....	18	75	58	....	10	39	....	....	28	....	247
	4th	....	17	7	17	60	33	....	10	52	....	....	21	....	217
Total		586	36	7	35	135	91	....	20	91	....	....	49	....	1,050
Alberta	1st	369	....	....	....	....	....	....	....	....	....	....	....	....	369
	2nd	....	....	6	40	82	71	....	....	44	11	2	....	....	256
	3rd	....	....	6	38	88	94	....	....	41	6	5	11	....	289
	4th	....	....	17	38	76	56	....	....	36	5	6	11	....	245
Total		369	....	29	116	246	221	....	....	121	22	13	22	....	1,159
British Columbia	1st	376	....	....	....	....	....	....	....	....	....	....	....	....	376
	2nd	227	....	....	....	....	....	....	....	....	....	....	....	....	227
	3rd	....	....	....	30	43	55	....	13	46	26	6	14	....	233
	4th	....	....	....	17	35	69	....	10	54	9	4	24	....	222
Total		603	....	....	47	78	124	....	23	100	35	10	38	....	1,058
Canadian Services Colleges															
Royal Military College (Kingston)	1st	70	....	....	....	....	....	....	....	....	....	....	....	....	70
	2nd	32	....	....	....	....	....	....	....	....	....	....	....	....	32
	3rd	....	....	....	6	34	28	....	....	24	....	....	4	....	96
	4th	....	....	....	8	22	26	....	....	24	....	....	1	....	81
Total		102	....	....	14	56	54	....	....	48	....	....	5	....	279
Royal Roads	1st	89	....	....	....	....	....	....	....	....	....	....	....	....	89
	2nd	7	....	....	5	6	14	....	....	11	....	....	12	....	55
Total		96	....	....	5	6	14	....	....	11	....	....	12	....	144
College Militaire Royal de St.-Jean	1st	103	....	....	....	....	....	....	....	....	....	....	....	....	103
	2nd	59	....	....	....	....	....	....	....	....	....	....	....	....	59
Total		162	....	....	....	....	....	....	....	....	....	....	....	....	162
Grand Total		6,768	36	36	898	2,316	2,020	108	145	1,513	208	149	738	5	14,940
Prospective 1961 Graduates		....	17	24	258	779	644	26	56	508	62	59	218	....	2,651

How to pull Industry and Commerce to a Planned Townsite and/or Industrial Park

LOW COST Central Heating

For factories • Shopping Plazas • Apartment Blocks • Schools • Churches





1 Located centrally in the Ajax Development this "furnace" is capable of supplying plentiful heat—or steam—to buildings within 2-mile radius with total coverage of over 16 square miles

2 "Main Street" is a happy street for factories at Ajax because there is no need for outlay in individual boiler-rooms. Over 20 factories are saving by using the central heat facilities.

3 "$12,000 added to net profits" (savings equal to 6% on an investment of $200,000) that's what central-heat means to the owners of the Ajax Apartment Development pictured here.

4 No capital cost of boiler-room—no labour cost—no boiler room maintenance or repair for shops in this 45 unit Plaza—at Ajax—using the central heat service. Pipes are underground immediately available.

*AJAX, ONTARIO... *has central heating plant which wipes out capital boiler room cost and all labour costs completely for scores of users—manufacturing and commercial plants, stores, apartment blocks, etc.*

The prime target in manufacturing must be to keep productivity high—and overhead low—if we, as Canadians, are to compete successfully. As Canada swings to an industrial economy more planned townsites like Ajax, Ontario, are developing with factories, commercial projects, plazas, homes, churches, schools, carefully, skilfully integrated by Canadian Architects and Engineers.

Into these ideal communities are being incorporated ultra-modern amenities and money-saving services. Central Heating is a notable example offering convenience, avoidance of capital and labour costs in individual heating plants, air-pollution control—and MONEY-SAVING resulting in lowered unit cost of all articles manufactured. Capable of burning any fuel these central heating plants can utilize whichever fuel is most economical.

Coal is—and will continue to be for decades to come—the most economical fuel in most communities. That's why it is the fuel used in the Ajax, Ontario Central Heating plant and most other central heating plants in this country. We suggest you investigate the Central Heating Plant Plan—for similar projects in your area.

**Ajax, Ontario is a planned community developed by Duffins Creek Estates Limited—a company jointly owned by Perini Limited and Principal Investments Limited.*

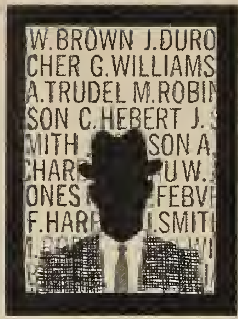
"Here's what central heating means to Commerce and Industry in Ajax" says Gordon Gilchrist . . . Chief Engineer at Ajax Heating Plant.

"Our plant at Ajax is adaptable to burning any fuel—oil, gas or coal—whichever will allow us to deliver heat or process steam cheapest to our customers. In this area nothing can equal coal for low cost so coal's the fuel we buy. With our modern stokers and ash-handling equipment one fuel is the same as any other as far as manpower is concerned."

For further information or additional case histories showing how other plants have saved money burning coal the modern way, write to Bituminous Coal Institute of Canada at 159 Bay Street, Toronto 1.

Where costs count—Coal is the fuel BCi **BITUMINOUS COAL INSTITUTE** OF CANADA

Personals



Dr. John Bertram Stirling, HON. M.E.I.C. (Queen's, B.A. '09 B. Eng. '11, LL.D., '51), installed Oct. 20 as the eighth Chancellor of Queen's University, said at the Convocation that engineers in growing numbers are replacing lawyers and accountants as managers in industry and business.

Dr. Stirling, president of E. G. M. Cape and Co. Limited, said engineers recently were elected Chancellors of four universities: They were: Dr. R. E. Powell, McGill University; Rt. Hon. C. D. Howe, Hon. M.E.I.C., Dalhousie University; Dr. C. J. Mackenzie, Hon. M.E.I.C., Carleton University and himself.

J. B. Stirling, HON. M.E.I.C.

Men with engineering training take a practical view of affairs, Dr. Stirling said in explanation of the trend.

The Chancellor, who obtained his bachelor of arts degree before taking engineering, said he felt the social sciences should be integrated to some extent with practical training in engineering.

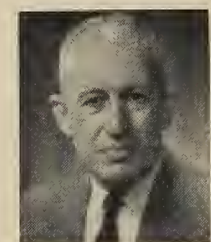
"To an engineer, the type of training given by an arts degree is very much of an advantage. It provides an education. Any strictly engineering course is inclined to be somewhat narrow.

"I don't think I would have gone nearly as far in my profession as I have," Dr. Stirling said, "if I had not taken an arts training as well as engineering. I have observed that in other successful executives as well."

G. H. Thompson, M.E.I.C., (McGill '13), has been named president of Calgary Power Ltd. He joined the company in 1925 and was appointed vice-president in 1941. He is also a director of the company.

Charles L. Brooks, M.E.I.C., (McGill '22), assistant general manager, Montreal area, the Bell Telephone Company of Canada, has retired.

H. W. Casperd, M.E.I.C. (London '28), has been appointed vice-president of Foundation of Canada Engineering Corporation Limited and will be in charge of Fenco's Toronto Office.



H. W. Casperd, M.E.I.C.

A. B. Hunt, M.E.I.C.

A. B. Hunt, M.E.I.C. (Toronto '28), has been promoted to vice-president, research and development, for Northern Electric Company.

Peter Corobow, M.E.I.C., has been appointed vice-president and general manager of the Chevalier Gaz Propane Limited.

H. R. Whitley, JR.E.I.C. will attend the University of Minnesota for a further year of graduate work in hydraulics. He has divided his time in England, between studies and work experience, under the Athlone Fellowship.

D. C. Bryden, M.E.I.C., (Alberta '28), has been appointed general manager of the City of Winnipeg Hydro-Electric System. He joined the company thirty years ago and before his promotion was assistant general manager.

D. C. Bryden, M.E.I.C.

J. Russo, M.E.I.C.

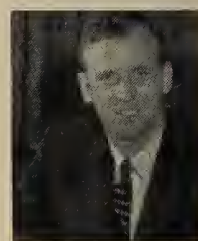
John Russo, M.E.I.C., (Belgrade '34), has been appointed general manager of BETA Construction Limited-General Contracors, Montreal.

Sam Roth, M.E.I.C., (McGill '48), has been appointed manager of the new Research and Development Department of Canadian Aviation Electronics Limited.

J. K. Ayles, M.E.I.C., (London '50), has been appointed division engineer with the Department of Highways and Transportation for the Swift Current area.

Harold B. S. Brownlow, M.E.I.C., has been chosen a member of The Select Group of about six North Americans by the Royal Society of Arts in London. Mr. Brownlow is projects manager and engineer for the construction by Golden Eagle Refining Company of Canada, Limited of a new oil refinery at Holyrood, Newfoundland.

H. B. S. Brownlow, M.E.I.C.



L. C. Webster, JR.E.I.C.

Lorne C. Webster, JR.E.I.C., (McGill '50), has been appointed assistant general manager for the Canadian Import Company.

Obituaries

James Earl Bennett, M.E.I.C. (Saskatchewan, '26), prominent design engineer for the Dominion Department of Agriculture, Prairie Farm Rehabilitation Administration, Regina, died July 2. Mr. Bennett became a member of the Institute in 1930 and was also a member of the Corporation of Professional Engineers of Saskatchewan.

Emmett Patrick Murphy, M.E.I.C., former deputy minister of Public Works of Canada in 1942, died June 17 in Ottawa. Mr. Murphy was a construction engineer and joined the Institute as a student member in 1909; he became a life member in 1950.

Albert Lawrence Killaly, HON. M.E.I.C., died September 9. He was 84. Mr. Killaly, a native of Prescott, Ont., was prominent in the canal engineering field. He became a student of the Institute in 1900 and was made an Honorary Member in 1953. On the formation of the Peterborough Branch in 1919 he was a member of the first executive. He was chairman of the Branch in 1925.

Other Societies

Lecture Tour

Dr. Evert Arne Bjerhammar of the Swedish Royal Institute of Technology is engaged in a two-month tour of United States engineering colleges. The tour is sponsored by the Engineers Joint Council and the American Society of Civil Engineers under a grant from the National Science Foundation, and is co-ordinated by the Surveying and Mapping Division of the ASCE.

Dr. Bjerhammar, Professor of Geodesy at the Royal Institute in Stockholm, is well-known in international surveying circles. His specialties include optical and electronic distance measuring devices, paralyx triangulation automatic mapping, and applications of the calculus of matrices to the method of least squares.

Canadian Soil Mechanics Conference

Field consolidation studies of marine sediments beneath earth embankments, river bank stability in glacial lacustrine deposits, and geotechnical properties of tills were among the topics discussed during the two-day Soil Mechanics Conference in Niagara Falls, Ont., in October. This was the 14th in a series of Soil Mechanics Conferences sponsored by the Associate Committee on Soil and Snow Mechanics of the National Research Council.

R. F. Legget, M.E.I.C., Ottawa, Chairman of the Associate Committee on Soil and Snow Mechanics, outlined the recent formation of the Geotechnical Division of the E.I.C.

More than 150 delegates heard three papers presented by geologists and seven by soil engineers. In addition, more than 30 formal discussions by invitation were presented as well as informal discussions from the floor.

NEC—AIEE

By co-ordination between the National Electronics Conference and the American Institute of Electrical Engineers, the national conference of the AIEE was held in Chicago in October, coinciding with the dates of NEC. Several jointly-sponsored technical sessions were presented.

During the NEC an award of $500 was given David K. Cheng and Mark T. Ma, both of Syracuse University, for their paper, "A Mathematical Approach for Linear Array Analysis." This annual award is given for an original paper presented during previous NEC adjudged the best on the bases of scholarship, originality, significance and clarity.

The American Society of Mechanical Engineers

Approximately 6,000 persons attended the Winter Annual Meeting of the ASME which was held in New York City Nov. 27-Dec. 2. Some 300 speakers addressed as many as 12 simultaneous sessions. Developments in aircraft, rockets, solar energy, power production, machine design and many industrial operations were among the topics covered. During the same week, the 1960 Exposition of Power and Mechanical Engineering, sponsored by ASME, was held at the New York Coliseum.

The Chemical Institute of Canada

A symposium on explosives technology was one of the features of the Canadian Chemical Engineering Conference sponsored by the Chemical Engineering Division of the Canadian Chemical Institute of Canada in Quebec City. Twenty-nine technical papers were presented. One session of papers on chemical engineering and computers featured a discussion on computers and control.

Coming Events

International Congress and Exposition of the Society of Automotive Engineers, Detroit, Jan. 9-13.

Annual Meeting of the Highway Research Board, Washington, D.C., Jan. 9-13.

Annual Meeting, American Astronautical Society, Dallas, Tex., Jan. 16-18.

Conference for Land and Construction Surveyors, Pennsylvania State University, Jan. 16-18.

Annual Meeting, American Physical Society, New York City, Jan. 31-Feb. 4.

Winter Convention on Military Electronics, Institute of Radio Engineers, San Francisco, Feb. 1-3.

Reinforced Plastics Division Conference, Chicago, Feb. 7-9.

Winter Meeting, International Institute of Sugar-Beet Researches, Brussels, Belgium, Feb. 21-22.

Conference of Protective Coatings Division, Chemical Institute of Canada, Toronto, Feb. 23.

Conference of Protective Coatings Division, Chemical Institute of Canada, Montreal, Feb. 24.

Annual Meeting, American Institute of Mining, Metallurgical and Petroleum Engineers Inc., St. Louis, Feb. 26-March 2. EIC

The Associations and Corporation

Ontario

The Association of Professional Engineers of Ontario has announced the winners of its $250 scholarship awards at University of Toronto, and Queen's University. The awards are presented annually by the Association to the student who, taking honors in engineering, obtains the highest standing in his work in the academic year.

This year's winners: U of T, last year, Yiu Chung Li, Toronto; 2nd year, G. M. Bragg, Islington; 3rd year, J. G. Heller, Toronto. Queen's: 1st year, Edward Langstaff, Rainy River; 2nd year, S. E. Frost, Port Hope; 3rd year, D. R. Morton, Kingston.

The entrance scholarship, awarded alternately to U of T and Queen's, was presented to Grant Davidson, Deep River, who is taking engineering physics at U of T.

British Columbia

Gold medallions signifying life membership in the Association of Professional Engineers of B.C. have been presented to R. A. Story and F. C. Underhill, both Vancouver. Presentations were made by H. P. J. Moorehead, Association president.

More than 250 municipal engineers, public works officials, municipal suppliers and their wives attended the 18th annual meeting of the Municipal Engineers' Division in Trail. Technical sessions and a business meeting were held.

News of the Branches

Assumption University

Dean G. Morrison, S.E.I.C.,
Correspondent

Election of officers constituted the main business of Assumption's first meeting of the season. Members are: chairman, William Pulleyblank; Vice Chairman, John Lindsey; Treasurer, Lloyd Kubis; Secretary, Dean Morrison; and course representatives William Lourette (chemical); Alan Pelanzer (Electrical); Kenneth Long (Civil); and Walter Sigmund (Mechanical).

Belleville

A. F. G. Tooth, M.E.I.C.,
Correspondent

Mr. A. E. Cross, regional Institute Vice President, was the guest at a smorgasbord offered by the Belleville Branch Nov. 14. A feature of the meeting was an illustrated talk concerning atomic reactor installation in Bombay, India, given by G. R. Adams, Vice-President and General Manager of Foundation Overseas Limited.

The Branch's first meeting was held Oct. 3, in the Assembly Hall of the Ontario Hydro Building. Chairman H. T. Floyd presided. Speakers were M. J. McInroy, Sales Service Manager, Automatic Electric Company, Toronto, and Donald Ross, City Engineer and Commissioner of Works, Kingston.

Mr. McInroy and Mr. Ross are members of a newly-formed organization known as the Committee for the Advancement of Professional Engineers, and this was the subject of their talks and subsequent discussions. Mr. McInroy dealt with the formation of CAPE, problems facing employee engineers, and the presentation of a brief to the Council of A.P.E.O. Mr. Ross dealt with employer-employee relations and the professional status of engineers, both of which, he said, could be improved through CAPE.

Border Cities

Wallace A. Macdonald, JR.E.I.C.,
Correspondent

Some 200 persons attended the Border Cities Branch annual dinner dance at the Essex Golf and Country Club, Oct. 21. Members and guests met for a reception and a smorgasbord dinner. Chairman James Reid expressed the Branch's delight concerning the attendance and the representation from the E.I.C. student section of Assumption University. Past Chairman Earl Dykeman was presented with a gold E.I.C. pin.

Mr. Pariset (left) chats with Halifax members during the Branch's mid-October meeting. To Mr. Pariset's left are: John Jay, secretary-treasurer; W. T. Windeler, program committee chairman; and G. H. Dunphy.

Brockville

D. B. Ashenden, JR.E.I.C.,
Correspondent

Thirty members are participating in the Branch's fifth lecture course of the Professional Development Committee. Interest in the course is keen, largely due to members of the committee.

The use of computers in Canada was the theme of an Oct. 24 meeting held at the Maitland, Ont., works of Du Pont of Canada. Speakers were R. N. Boyd, M.E.I.C., Supervising Engineer, Montreal Engineering Department, Du Pont of Canada, and N. P. Turner, Controls Systems Engineer, Maitland Works, Du Pont of Canada.

Mr. Boyd said the three great advances of the present age were, energy, automation and computers. He said computers would be responsible for the greatest ultimate benefit in that they would revolutionize engineering. They can dispose of guesswork and lead to better and more economical conclusions. He differentiated between digital computers, capable of sixth grade mathematics, and analog computers which are capable of solving complex differential equations.

One of the principles of using computers is to train engineers to recognize paying problems and stimulate an analytical approach. To encourage and stimulate use of computers, Mr. Boyd's company established a course in advanced mathematics for engineers given by a McGill University professor. Sixty engineers volunteered for the course which consisted of 41 three-hour lectures twice a week.

A major application of computers by Du Pont has been the complete stimulation of a new chemical plant. This enabled operators to practise their functions before the plant had been built.

Mr. Turner demonstrated the use of the analog computer in the Maitland Works. As an example, Mr. Turner took a tank being filled and emptied at various rates with automatic level controls. The various perameters which affected the level in the tank were presented in mathematical form, and connected to the analog computer. Any of the variable quantities, such as the cross section area of the tank, could be changed to show the resultant changes in other variables.

Lively discussion followed the talks. The speakers were introduced by H. Gilchrist, and thanked by Mr. Ashenden.

Calgary

R. L. Turner, S.E.I.C.,
Correspondent

The second weekly meeting of the season was held early in October. After a roast beef lunch, 28 members listened to a talk by Mr. Henninger concerning "Thrift and Saving". Mr. Henninger said we should pay ourselves a salary in the form of savings from our earnings. Following the Branch's first dinner meeting, Bert Howard described his trip to Russia.

Cape Breton

Lloyd Boutilier, M.E.I.C.,
Correspondent

Guest speaker at the Oct. 17 meeting of the Branch was Lt.-Col. Ed. Thorpe, Civil Defence Co-Ordinator for Cape Breton and Commanding Officer, 2nd Battalion, Nova Scotia Highlanders Militia. His subject was national survival.

Lt.-Col. Thorpe discussed preparation for survival from an atomic blast, the danger of fallout and the quantity of radiation which produces various degrees of injury. The Army is the most responsible force in survival training, he said, but other organizations and groups, such as police, firemen, engineers, welfare and rescue personnel must be trained to participate. He stressed the importance of engineers in restoring services following such an attack. Lt.-Col. Thorpe also outlined the structure of the Emergency Measures Organization in Canada.

A film, "Radioactive Fallout", and a question period followed the talk. Lt.-Col. Thorpe was introduced by Branch Vice-Chairman Rod Bradley, and was thanked by Vince Palmer.

Central B.C.

A. F. Joplin, M.E.I.C.,
Correspondent

A joint meeting of the Central B.C. Branches of the Institute and of the Association of Professional Engineers of B.C. was held at the Kamloops Golf Club Oct. 21. Following dinner a business session was held under the direction of Branch Chairman H. A. Price who also reported on the Institute's Annual General Meeting.

Guest speaker E. Davis, Superintendent, Kamloops Branch, British Columbia Telephone Company, described "What Happens When You Lift Your Telephone Receiver." Mr. Davis discussed automatic telephone equipment, illustrating his points with a model of a line finder switch. He explained how each selection chooses the path dialed. Mr. Davis also discussed operator distant dialing now in operation for long-distance calling by operators, and direct distance dialing which rapidly is being placed in service at the Kamloops exchange.

Following the talk was a visit to the

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• NEWS OF THE BRANCHES

(Continued from page 110)

Kamloops exchange which now is being converted from manual to dial equipment. All were impressed with the magnitude of the change-over and the multiplicity of the company's operations, which include transmission of television for the local station. Highlights were direct dialing to New York City and a call to an operator in Honolulu. The change-over is expected to be finished in the spring.

Halifax

H. F. Peters, M.E.I.C.,
Correspondent

Ernest Pariset of Montreal's LaSalle Hydraulic Laboratories discussed developments in hydraulic turbines at the Oct. 18 meeting of Halifax Branch. M. Pariset, who came to Canada from France five years ago, substituted for Pierre Danel, a noted French hydraulics expert who was forced to cancel his visit because of illness.

M. Pariset described in detail the effects of recent research in improving the efficiency of turbines and extending their efficiency over a greater range of specific speeds. Of special interest was the development of the ball turbine in which the generator is mounted underwater and closely connected to the turbine which is of the variable pitch type. The unit can be mounted at any angle such as tidal power plants. M. Pariset also discussed some of the considerations governing tidal power. He illustrated his talk with slides. Two French films were shown following the discussion.

Kingston

R. O. McGee, Superintendent of Patents, Department of National Defence, was guest speaker at an October meeting of Kingston Branch. Mr. McGee discussed the nature of the patentable invention and the relationship of the engineering works to patents. These included a brief discussion of other forms of industrial property protection such as trademarks and copyright, procedures involved in obtaining a patent, the rights of a patentee and the infringement of a patent. There was a reference to the respective rights of employee and employer in inventions.

Kitchener

A. R. LeFeuvre, M.E.I.C.,
Correspondent

Thirty-five members of the Branch took part Oct. 27, in an interesting field trip through the Guelph plant of Federal Wire & Cable Limited. Refreshments were served by the company following the tour.

Lethbridge

P. A. Harding, JR.E.I.C.,
Correspondent

The Can-Pack method of beef processing was explained at the Oct. 29 meeting of Lethbridge Branch by Fraser Gardiner, M.E.I.C., construction engineer with Canada Packers Limited, Toronto. Mr. Gardiner first explained the older, bed system of beef processing in which the employee works much harder and in more tiring positions. The Can-Pack method employes a variable-speed conveyor which carries the work to the employee.

The worker stands on a platform which can be raised or lowered by a foot-controlled compressed air device. The method allows more efficient use of tools such as the hide cutter, bone cutter and tail puller. Mr. Gardiner said average per capita consumption of meat in Canada is 143 pounds, of which 64 pounds are beef. Automation also was well illustrated by a film showing the hydrogenation of oils. In closing, Mr. Gardiner said the packing plant now being completed in Lethbridge will dress approximately 1,000 cattle a week.

Montreal

J. R. Sabourin, M.E.I.C.,
Correspondent

Le Chapître de Montréal est celui qui comprend le plus de membres de tous les groupements régionaux de l'Institut des Ingénieurs du Canada. Ses activités diverses couvrent un vaste champ d'action, et à ce sujet trois projets importants mis de l'avant récemment, seront en voie d'exécution dans un avenir très prochain.

The Special Meetings Section of the Program Committee is organizing a two-day Regional Technical Conference at the Mount Royal Hotel on April 6th and 7th, 1961. The subject is Urban Transportation — a live topic in Montreal and one in which all members are vitally interested.

The Branch is assisting Headquarters in organizing a Joint Hydraulic Conference to be held in Montreal on May 7th to May 10th, 1961 by the E.I.C. in co-operation with the A.S.M.E. Most of the papers will deal with hydraulic machinery, but some 18 papers from Canadians will give a civil slant.

Le Comité d'orientation des étudiants du Chapître de Montréal a offert son appui à l'Institut de Chimie du Canada dans la promotion d'une Exposition des Sciences destinées aux étudiants des cours supérieurs, les 7 et 8 avril prochain. Ceci est en outre des activités régulières de ce comité dont la fonction principale est de conseiller et d'orienter les étudiants destinés aux de génie.

The Evening Education Committee is making arrangements with McGill to give evening courses which will permit one to qualify as a member of the Institution of Mechanical Engineers and as a member of the C.P.E.Q. Courses will begin at the third year engineering level and, if they prove successful for mechanical engineers, the courses will be enlarged to include other branches of engineering.

Une section d'étudiants, la première du genre dans la région de Montréal, est présentement en voie de formation au Collège Loyola. Elle est activement supporté par la section junior de l'Institut et un comité spécial composé de membres a été créé dans le but d'encourager la formation de groupements semblables dans les autres universités.

The Junior Section recently polled

the members enquiring into the desirability of forming a Social Club. Two-thirds of the replies were favourable. Although 1200 engineers have indicated a willingness to join a Social Club, the cost of forming one would be substantial and, as a result, the Junior Section is making a careful investigation of all facets before proceeding further. The Junior Section strongly believes that a Social Club would provide the members of the Montreal Branch with a very worthwhile service and that the prestige of the E.I.C. would be substantially increased.

La Direction a décidé à l'avenir d'émettre sous forme bilingue tous les bulletins de scrutin, factures, et formules d'application jusqu'ici uniquement rédigés dans la langue anglaise. Le Chapître de Montréal entrevoit également dans l'avenir prochain la publication dans les deux langues de tous les pamphlets, bulletins, et brochures destinés à ses membres.

The Branch sponsors at least one technical meeting per week. Of interest to all is a series on labor relations subjects organized by the Management Section. In November there was a talk on conciliation. In December there will be a discussion on the contentious subject of professionalism versus unionism for engineers. In late January or early February a meeting will consider labor unions and automation. Members are urged to read the Program Notices to make certain they are not missing a talk of prime importance.

Newfoundland

Anthony O. Nemec, JR.E.I.C.,
Correspondent

The main topic considered at the Oct. 19 meeting was the proposed Newfoundland Engineering Conference to be held next autumn at the new Memorial University. It is proposed to have a series of technical papers given by engineers from the local branch, and by other engineers working in Newfoundland.

Niagara

E. C. Little, M.E.I.C.,
Correspondent

The Oct. 13 meeting of Niagara Branch was held in connection with the 14th Soil Mechanics Conference in Niagara Falls. Guest speaker was Toronto consulting engineer Dr. H. Q. Golder. He discussed features of soil mechanics he had encountered during his career. The conference, sponsored by the National Research Council, attracted about 150 engineers.

Nipissing and Upper Ottawa

J. W. Millar, M.E.I.C.,
Correspondent

Forty-two members and guests were present at a dinner meeting Nov. 2 which inaugurated the Branch's activities for the season. The meeting coincided with the date of the official opening of the Sewage Treatment Plant for North Bay, West Ferris and Widdifield. Guest speaker was D. S. Caverly, M.E.I.C., director of plant operations of the Ontario Water Resources Commission. Mr. Caverly was assisted by B.C. Palmer, supervisor of sewage works of the O.W.R.C.

Mr. Caverly outlined the history, organization and activities of the O.W.R.C. He said the North Bay plant is unique in that the methane gas given off in the process of digesting the sewage will be used to heat the incoming sewage, to power the air compressors and to heat the central building.

University of Saskatchewan

Arthur F. Hinderks
Correspondent

The role of the mechanical engineer in the chemical industry was explained to the Oct. 12 meeting by R. N. Boyd, Supervisor of Engineer Design Services, Engineering Department, Du Pont of Canada Limited.

Mr. Boyd discussed the various roles which may be played by newly-graduated mechanical engineers. Industry today is expanding continually, he said, and mechanical engineers are playing an ever-increasing part in this expansion. The highlight of Mr. Boyd's discussion was a film on Du Pont of Canada. The film gave a general picture of the industry, then showed the various phases in which a mechanical engineer can find challenging situations. A lively, informal discussion session and a question period followed.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Catalytic Construction of Canada Limited is the winner of the E.I.C. Certificate of Advertising Merit for the month of September 1960.

Their 4-color advertisement headed: "VISION Seeing ahead" is one of an historic series and links the vision of Jacques Cartier with the vision of Catalytic Construction of Canada Limited. The whole advertisement is very striking and the illustration is different to that usually found in trade or technical periodicals.

The judging of the advertisements was done by fifty readers of the "Journal" — five from each province — who made their selection from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

Catalytic Construction of Canada Limited is headed by G. R. Henderson, M.E.I.C., and the advertising agency who prepared and placed the advertisement is Clifton Train & Associates—Clifton Train being the Account Executive.

CATALYTIC CONSTRUCTION OF CANADA LIMITED WINS CERTIFICATE

The four color full page advertisement of Catalytic Construction of Canada Limited which appeared on page 135 of the September issue was judged the "best" in the issue by a fifty reader jury. The Canadian organization is headed by G. R. Henderson, M.E.I.C. and the advertisement was prepared and placed by Clifton Train & Associates — Clifton Train, A/E.

Toronto

D. R. Abbey, M.E.I.C.,
Correspondent

More than 100 members attended a Nov. 2 meeting to hear French hydraulics expert Pierre Danel. Due to an indisposition, the paper was presented by M. Danel's associate, M. Pariset. After its presentation M. Danel discussed several aspects of the work in reply to questions.

Neil McMurtrie, Design Engineer, Transmission Section, Ontario Hydro, addressed the Electrical Section Oct. 11 on the subject "Extra High Voltage Transmission at the Coldwater Project." The Coldwater project is a pilot study of the problems associated with extra high voltage transmission. The subject is becoming increasingly important. Available sites for development of hydraulic generators are becoming more distant from points of power usage.

In a joint meeting with the Chemical Institute of Canada, the Power Section heard a paper on water treatment practices for the power industry. The paper was presented by Eugene Driscoll of the Technical Department of the Permutit Corporation.

On Oct. 27, C. G. Miller, Products Manager, Graver Tank & Manufacturing Co., presented a paper on the theory and application of Geodisic Dome Construction. The speaker traced the development of geodisic theory, its adaptation to the practical needs of construction, and the erection of a 384 ft. diameter dome.

• DISCUSSION

(Continued from page 81)

The task of presenting, in a short paper, the principles of automatic control could be undertaken only by such an outstanding expert as Dr. Porter. Even then one has a feeling that the presentation is too specific for the general reader and too general for the professional.

I would like to devote this brief discussion to:

1) a few remarks about some popular misconceptions in the field of automatic control and
2) a suggestion in what field of automatic control the research is particularly necessary.

It is unfortunate that the concept of "feedback" is not taught much earlier than in Electronics or Automatic Controls. The most natural place would be in the study of Mechanics. It is about time to realize that Newton's Third Law, for instance, is nothing but the action of "negative feedback".

It is fashionable to talk about "information-handling" capabilities of feedback systems. Unfortunately, the word "information" has anthropomorphic connotations which probably account for its popularity, but add little to understanding. The real implication is that feedback in automatic control is used to transmit signals from one part of the system to the other.

It is extremely annoying to hear about the "intelligence" and "reasoning" capacity of digital computers as if they were the only examples of systems exhibiting such characteristics. The truth being of course, that any analog computer has the same properties. Thus an analog integrator has a "memory", an analog differentiator can "predict" future and an analog adder can "decide".

Following the common practice of Operations Research, one has to "optimize" everything these days. It is questionable whether one should talk about the "optimization" of a complex nonlinear system. One cannot "optimize" a system whose analytical characteristics are not known.

The subject of "adaptive" systems is very popular today. One must remember however that such systems are not peculiar to the availability of electronic circuitry and computers. An automatic gearshift of our modern cars is a very good example of such an "adaptive" system to which one could attribute a very "intelligent" behavior indeed!

The field of linear automatic control theory is certainly very well developed. We can not say the same about its *nonlinear counterpart*. As far as the theory of *large systems* is concerned, neither the linear or nonlinear varieties have been yet really touched. I would like therefore to end this discussion with the suggestion, that more effort be exerted towards the understanding of the behavior of systems in these almost virgin fields. Let us "understand" first, and "optimize" later!

Discussion by J. H. Milsum:

Dr. Porter has prepared an important paper. There is always need for thoughtful searching and provocative evaluations of a new science, and for prediction of its future trends. The timing is opportune in view of the current "coalescing of the computer and automatic control branches" as Dr. Porter says; incidentally, a more directly-applicable metaphor might be "a fruitful growth from the cross-fertilization of these two fields"! The paper's value derives from Dr. Porter's attempted synthesis, for the purpose of better control systems, of the ideas behind such subjects as information theory, learning machines, multi-variable searchers and adaptive goal-seeking. The continued references throughout the paper to biological adaptive systems implies that important results should ensue from cross-fertilization between these fields also!

To this discussor, the paper divides into two parts which are approximately characterized by the two principles of automatic control which Dr. Porter enunciates;

Feedback: In this half the basically deterministic type of control system is discussed, including the adaptive or optimizing type and including deterministic systems subjected to stochastic signals. Some comments follow below.

Noise Generation: Self-organizing control systems inevitably must operate on a probabilistic basis. Conditional probability appears to be a basic tool here in the pattern recognition needed for learning ability. One might wonder however whether the ability to store, and learn from, past data might not be considered principles in their own right.

In the broad review conducted in this paper Dr. Porter only briefly mentions some important subjects in which much progress remains to be made;

Sampled-data systems, with their ability to time-divide a controller among many control systems.

Non-linearity of all systems, which becomes particularly important as systems are optimized (both the inherent non-linearities, e.g. friction and saturation, and the designed non-linearities, e.g. bang-bang controllers).

The practising control engineer cannot expect any help from this paper in deciding on conventional controller adjustments in a particular problem; but he will find prediction of the problem he will be confronting in future years.

Adaptive Control

The following comments relate to adaptive control. It is worth reemphasizing that feedback itself introduced the first measure of adaptability to controllable system-disturbances. As closed-loop theory was developed, the 'tolerance' of a system to disturbances came under closer scrutiny, and adaptive or optimizing techniques were considered. Optimization conceptually requires a second 'executive' control loop so that optimal operation is obtained according to some criterion. A common, obvious criterion of optimality is an economic one, and one large-scale example in use today is linear programming applied to manufacturing and distributing processes. Control is of course discrete because the large-scale computer calculations necessary are only carried out periodically. However the principle is the same as in conventional engineering control systems. In the high-performance aircraft field adaptive auto-pilots have become necessary, and a universal auto-pilot which can fly all aircraft without preference is already a possibility.[1]

Model Control

Under 'Prediction and Feedback' the author discusses three techniques which use models of the process in the control system. This discussor feels that the conceptual advantage of the methods of Fig. 3 and 4 are not easily realized mathematically when one designs the system. Thus the dotted-box of Fig. 3 is critical and does not exist in the Reswick method (Fig. 4). In a forthcoming paper[2] Reswick shows that the main application of his method is for the rather special case of a pure time-delay process. It is not clear to the discussor that genuine prediction exists in either of these methods. The author's own sampled-data method (Fig. 5) does involve prediction but the use of the polynomial model is not clearly explained, and Fig. 5 does not help very much.

End-Point Controllers

This last method bears on the subject of end-point controllers as in automatic landing of aircraft, stopping of elevators and completion of batch chemical reactions. The end-point is here the critical performance index, and predictive-model controllers have a fruitful application.[3]

Correlation Work

The Delay Line Synthesiser (DLS) provides an approximation to the impulse response by a discrete set of values in time. However the DLS can accept either continuous or discrete signals.

The author emphasizes that an automatic control must reject random information. However in the suggested use of the DLS the system is interrogated as to its transfer function by purposeful introduction of random signals, which do not interfere with normal operation. One of the new adaptive auto-pilots is incorporating this technique. Again it is interesting that interceptor pilots are known to interrogate their aircraft subconsciously with a high-frequency low amplitude oscillation of controls.

References

(1) "Summary and Status of Adaptive Control System Program" Capt. R. R. Rath—presented at the "Adaptive Flight Control Systems" Symposium, Wright-Patterson Air Force Base, Ohio, 13-14 January 1959.
(2) "A Dead-Time Controller" J. O. Reswick, Forthcoming paper at International Federation of Automatic Control — Moscow, July, 1960.
(3) Leffcowitz, I., Eckman, D. P. "Principles of Model Techniques in Optimizing Control". Forthcoming paper at International Federation of Automatic Control —Moscow, July 1960.

Discussion by G. L. d'Ombrain

Dr. Porter's paper is a most valuable statement of the position of automatic control today and in the future. I would like to confine my remarks to the work which is likely to be pursued, indeed is being pursued currently, in this field in the context of Dr. Porter's remarks.

In the past, considerable attention has been given to attempts to determine the characteristics of processes with a view to being able to control them more adequately. The idea has been that if we could stimulate processes adequately on an analogue computer then we should be able to design control systems with intelligence in order to get an optimized control. While much effort has been put into this, I do not think that the control engineer can with honesty say that he has succeeded to any real extent. The reasons for this are manifold. The obvious one is often quoted that plant managers do not like having plants interfered with, and this of course is true. But even where pilot scale plants have been organized and instrumented to obtain the appropriate knowledge, the interpretation of this knowledge has been exceedingly difficult since most plants are highly non-linear.

Reswick propounded ideas using auto- and cross-correlation which would enable, in theory, the process transfer characteristic to be determined utilizing normal plant operating records. The type of instrumentation required is not normally present on plants. The methods also necessitate linear theory and there obviously has to be an engineering approximation, therefore, in the interpretation of results that are obtained. The self-optimizing, and decision taking forms of control as outlined in Dr. Porter's paper seem to suggest a much more satisfactory approach. Here we may neglect the non-linear behavior of the process, we may to a certain extent ignore the problem of predicting its transfer characteristic, and we may make the computer itself do much of this work for us.

I would ask the author whether it is a correct interpretation of his paper to suggest that the immediate future will see processes being controlled on a number of minor loops as they are today utilizing those variables which have fast times of response, so that the control loops have rapid responses, properties for example such as temperature, pressure, level, flow, to a lesser degree pH, conductivity, etc. Added to this will be some decision taking type controller with inbuilt optimizing features which will be fed with appropriate information from instruments usually of analysis form which are not necessarily fast response in themselves, such as gas chromatographs, and that this information will be acted upon by the controller to deliver information which allows the alteration automatically of the set points of the appropriate minor loops. The reluctant break away from pneumatic to electric controllers which has swept through the instrument manufacturers in the last two or three years should help this approach considerably.

Discussion by V. J. Bakanowski, M.E.I.C.

In studies of dynamics of chemical processes it appears, judging from a cross-section of contents of technical papers published on this subject that the chemical industry is ahead of most of the universities in their work in this field. Of course we, in the chemical industry, would like to see the universities develop a substantial lead in the field since this would provide the best guarantee in future for firm and sure progress of chemical process control methods.

It is therefore very encouraging to read Dr. Porter's paper. It provides assurance that in the not too distant future when our knowledge on chemical processes, techniques for their mathematical formulation and hardware are improved, the universities will show us the way to apply the new analytical methods which Dr. Porter is developing today.

Author's reply:

Professor Glinski's remarks are of a very general nature and are not specifically concerned with the paper. However, he has raised several controversial points which must be challenged. For example, he suggests that the concept of "feedback" should be introduced in the study of Mechanics and he further suggests that Newton's Third Law exemplifies the principle of negative feedback and should be taught accordingly. This appears to me to be a retrograde step. Engineering students already have enough to cope with in understanding and applying the principles of Mechanics without introducing unjustifiable complications. It is well known that negative feedback characterizes many processes — physical, biological and sociological — but, in introducing students to these subjects, it is surely inadvisable to confuse them with a hierarchy of more and more abstruse ideas before they have understood the basic elements.

Professor Glinski objects to the use of the term "information" in feedback control. But it is difficult to understand why, because today communication theory, and the concept of measuring information, is proving a valuable aid in control system engineering. We do handle information in controlling processes and "information" is surely a respectable word. I agree with Professor Glinski that it is highly undesirable to talk about the "intelligence" and "reasoning" capacity of digital computers, but I strongly disagree that such properties may be associated with analogue computers. Further, I am astounded to read that "an analogue differentiator" can "predict" the future—this is, of course, nonsense. The suggestion that it is not possible to optimize a system whose analytical characteristics are not known, is of course true, but it is also impossible to optimize a process whose analytical characteristics are known because the environment cannot be predicted. And I fear that Professor Glinski has misunderstood the main arguments considered in the paper which suggests that at least some improvement of performance can usually be achieved by effective utilization of information appertaining to the process and to its environment.

I am grateful to Dr. Milsum for raising several important items. I agree that with the limited length of the paper several highly important aspects of control system technology were omitted. For example, sampled-data systems are likely to prove more and more significant for the reason mentioned by Dr. Milsum and also because a sampled system may, in many cases, prove optimum from the standpoint of information assimilation. In so far as non-linearity is concerned one might expect that the probabilistic approach to control system optimization may, in the future, by-pass some of the difficulties inherent in the design of non-linear control systems. However, the answer to this question is not likely to be available for several years. I am grateful for Dr. Milsum's comments on adaptive control which indicate that the subject can be "brought down to earth"—the example of the high-performance aircraft auto-pilot is particularly appropriate and I hope the universal system at present under development proves as effective as theory suggests.

Since the paper is intended necessarily to discuss principles rather than techniques it was perhaps excusable that the methods of Fig. 3 and 4 should be introduced to exemplify important principles. I agree with Dr. Milsum that the Reswick and Lang-Ham techniques are to a large extent of academic interest only.

I think some misunderstanding has arisen in connection with the role of random information in adaptive systems. My point is that if the environment is absolutely random and if the process is characterized by a very wide band-width it is not possible to introduce meaningful automatic control because prediction is impossible. I believe the purposeful introduction of random signals as a sort of search mechanism is of the highest importance and I am glad that Dr. Milsum agrees with this view.

I am very impressed with the competent summing-up by Dr. d'Ombrain of the more important principles introduced in the paper. For example, it is interesting to note that Dr. d'Ombrain also suggests that non-linear behaviour of a process may not preclude its optimization by means of probabilistic pattern recognition techniques. On the whole, I agree with the interpretation that the future evolution of automatic control will increasingly involve the decision-taking type of controller utilizing information from elaborate analytical instruments, and subsequently establishing behavioural patterns which in turn will be utilized to modify the minor loop set-points in a manner tending to satisfy process goals.

It is particularly gratifying to note the comments by Mr. Bakanowski. It seems to me that the role of universities in such fields as control technology is to explore more profound concepts and to speculate on advances which may not perhaps come into effect for many years. Industrial research and development laboratories cannot be expected to undertake much speculative research because of the importance of dealing with day-to-day problems and problems which may arise within, say, the next five years. However, the university research worker certainly requires the encouragement of his industrial colleague and thereby really effective collaboration between the two complementary groups of research workers will be strengthened.

WANTED

NOVEMBER 1960 ISSUE

The Engineering Journal

The Engineering Institute has received so many requests for additional copies of the November issue of The Engineering Journal that the available supply has been exhausted.

It would be greatly appreciated if readers who do not keep their copies on permanent file, will return them to the editorial office at:

900 Sherbrooke St. West
Montreal 2, Que.

Library Notes

Prepared by the Library, The Engineering Institute of Canada

Book notes marked by an asterisk have been provided through the courtesy of The Engineering Societies Library in New York.

REINFORCED CONCRETE CHIMNEYS, 2nd. ed.

Since the publication of the first edition in 1940, Mr. C. P. Taylor, one of the authors has died, and this edition has been revised by Mr. Turner. Recent information has been included in this edition, as is an improved method of analysing annular sections subjected to bending and direct thrust. U.S. specifications for reinforced concrete chimneys are referred to, and wind forces have been reconsidered in the light of recent aerodynamic experiments. A new chapter deals with deflection and sway. Other topics covered are temperature, stresses, and flue openings. An example of the complete design of a chimney is given, and there is a bibliography of 21 items. (C. P. Taylor and Leslie Turner. London, Concrete Publications, 1960. 81 p., $2.80.)

CALCUL DES PROBABILITIES EN VUE DES APPLICATIONS

A basic introduction to the principles of calculation of probabilties, commencing with a review of stochastic mathematics and games theory. The various theorems and laws relating to probabilities are discussed and explained, and numerous worked examples given. This volume is one in a series on probability, statistics and operations research. (Maurice Girault. Paris, Dunod, 1960. 162 p., 14.50 N. Fr.)

THE ENGINEERING INSTITUTE LIBRARY

The publications mentioned in these notes are now available in the Library, and may be borrowed by members of the Institute. Two items may be borrowed at one time, for a period of two weeks, excluding time in transit.

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

***STRUCTURAL ANALYSIS OF "UNISTRUT" SPACE-FRAME ROOFS.**

The two parts of this report cover the recommended method for computation of safe roof loads and the tables of computed factors to be used in safe load computations. The volume of text analyses "Unistrut" space-frame construction empirically, with a history of its development, and its general behavior on various types of supports, and outlines the general theories on which the analysis is based. The proposed method of computation is then applied to five test structures with the results of the tests, and then to a series of untested structures. The tables in Part B present computations of distribution factors, carry-over factors, and fixed-end moments. (P.H. Coy. Ann Arbor, University of Michigan Press, 1959. 2 volumes, $18.00.)

***FUEL CELLS.**

This volume contains the papers and subsequent panel discussion heard at a 1959 Symposium sponsored by the American Chemical Society. The nine papers include a general introduction to fuel cells, and discussion of high-and low-temperature hydrogen-oxygen fuel cells, carbonaceous fuel cells, the electrode processes in fuel gas cells, molten alkali carbonate cells, catalysis of fuel-cell electrode reactions, and electrode kinetics of low-temperature hydrogen-oxygen fuel cells. (Ed. by G. J. Young. New York, Reinhold, 1960. 154p., $5.75.)

***GLASS: ITS INDUSTRIAL APPLICATIONS.**

This book covers the manufacture, the physical and chemical properties, and, particularly, the applications of all types of glass. It is semi-technical and is directed to those involved in the design, specification, testing, fabrication, purchase, or sale of glass products, rather than to glass manufacturers. The information given here reflects recent advances in the field and includes new information on such subjects as glass bead reflectroization and the "float glass" process for making flat glass. (C. J. Phillips. New York, Reinhold, 1960. 252p., $6.95.)

***INFRARED RADIATION.**

This book presents information on the components of infrared radiation units and the laws of physics by which they operate. It then outlines the applications and potentialities of infrared in science, medicine, technology, and industry. A generalized infrared system is developed step by step from the source of the signal through the methods of transmission to the final display. The latest material on infrared artificial sources, research in wavelength transmission, infrared instruments, detectors, and spectroscopy is given. (H. L. Hackforth. Toronto, McGraw-Hill, 1960. 303p., $11.50.)

***CONTROL SYSTEMS ENGINEERING.**

The specialized backgrounds of eleven authorities have been integrated into this single concise volume covering the mathematical aspects of control-systems engineering as applied to the study of complex large-scale automatic control systems. The role of mathematical models is indicated, and there is thorough coverage of modern theory from the trial and error procedures used in the design of linear systems to the application of game theory in the synthesis of complex systems. The background material on feedback theory, matrix methods, statistical theory, systems analyses, time-domain synthesis, sampled-data systems, etc. is directed toward the control engineer who wished to use mathematics in his procedures. (Ed. by W. W. Seifert and C. W. Steeg, Jr. Toronto, McGraw-Hill, 1960. 964p., $17.25.)

***WATER SUPPLY AND SEWERAGE, 4TH. ED.**

Presupposing a knowledge of hydraulics, this revised edition presents principles and present-day practices, introducing the subject with a discussion of sanitary engineering in modern life—the role of the sanitary engineer, the relation of population to consumption and disposal, and other problems. The supply of water is discussed in detail, including sources, collection and distribution, quality, clarification and filtration, and pumping stations. Sewerage is fully treated from the standpoint of sewer design, construction, maintenance, characteristics and flow; sewage disposal, sedimentation and filtration; sludge treatment and disposal; and miscellaneous problems. The final chapter discusses financing and management of the relevant plants and systems. (E. W. Steel. Toronto, McGraw-Hill, 1960. 655p., $12.75.)

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*WELDING HANDBOOK, SECTION THREE: MISCELLANEOUS METAL JOINING AND CUTTING PROCESSES, 4TH ED.

Inclusion of chapters on the adhesive bonding of metals and the welding of plastics in this handbook marks the recognition by the AWS of adhesives as structural materials and of plastics as weldable materials. Other topics covered include forge, thermit, induction, ultrasonic, and stud welding, welding by cold working, surfacing, brazing, soldering, arc and oxygen cutting, and metal and ceramic spraying. Section 1 of the Handbook—General; Section 2—Gas, arc & resistance welding processes; sections 4 & 5 to follow. (Ed. A. L. Phillips. New York, American Welding Society, 1959. $9.00, various pagings.)

*THE DYMAXION WORLD OF BUCKMINSTER FULLER.

This book reflects the author's impressions and interpretations of the life and work of Richard Buckmaster Fuller, whose "Dymaxion" idea—getting from any type of structure the maximum net performance per unit of energy input—has created over the past thirty years a steady stream of startling cars, houses, maps, domes and systems of mathematics. Admittedly biased by personal warmth, the author's account is vastly interesting, and nearly 200 pages of superb glossy annotated photographs further illustrate the man and his work. (R. W. Marks. New York, Reinhold, 1960. 232p., $12.00.)

*VACUUM METALLURGY CONFERENCE, 1959: TRANSACTIONS.

The papers of the third annual conference held in June 1959 discuss new developments in vacuum arc melting and casting, vacuum investment casting, vacuum induction melting, vacuum degassing, electron-beam techniques, and applications of the products of vacuum metallurgy. (Ed. by R. F. Bunshah. New York, University Press, 1960. 212p., $7.50).

*DESIGN OF STEEL STRUCTURES.

This book emphasizes the fundamental principles of structural mechanics, the behavior of actual and idealized structures, and such practical requirements as safety, feasibility, and economy, correlating these concepts with current design practice. It is intended as a textbook in both elementary and advanced civil engineering courses. Following a general introduction to structural design principles the book covers elasticity, plasticity and safety, riveted, bolted, pinned and welded connections, tension compression and light-gage members, beams and girders, and the design of steel bridges and of steel buildings. (B. Bresler and T. Y. Lin. New York, Wiley, 1960. 710p., $9.75.)

*DECISIONS UNDER UNCERTAINTY; DRILLING DECISIONS BY OIL AND GAS OPERATORS.

The first objective of this book is to describe problems in drilling for gas and oil — to drill or not to drill — and how business men actually make drilling decisions. The second objective is to explore the possibilities of the application of mathematical theories to such decisions. The methods suggested for this purpose are clear and simple, requiring only a working knowledge of arithmetic and high school algebra. (C. Jackson Grayson, Jr. Boston, Division of Research, Harvard Business School, 1960. 402p., $6.00.)

*1959 REFERENCES ON FATIGUE.

This is a list of references published in 1959 dealing with the fatigue of structures and materials. Brief abstracts are included where available, and the references are arranged so that the sheets may be cut apart for filing as desired. This is the tenth volume in the series, which covers references published 1950 to 1959. (Philadelphia, American Society for Testing Materials, 1959. 88p., $4.00. s.t.p. 9-K.)

*ELEMENTARY INTRODUCTION TO NUCLEAR REACTOR PHYSICS.

This textbook for undergraduates in physics and engineering is an elementary account of that branch of physics involved in the study and design of nuclear reactors. The first three chapters deal with fundamental aspects of nuclear physics directly related to the physics of nuclear reactors. The discussion then develops the concepts of the compound nucleus, neutron cross-sections, and their relationship, and examines the physical aspects of nuclear fission, the interaction of neutrons with matter in bulk, and thermal and fission neutrons. Neutron diffusion theory then is considered, and the non-stationary reactor described and explained. The concluding chapters deal with the detection, measurement, and safeguards against nuclear reactor radiations. (S. E. Liverhant. New York, Wiley, 1960. 447p., $9.75.)

FUNDAMENTALS OF TRANSISTOR PHYSICS.

A broad introduction to the field of transistors, providing an analysis of the action of semi-conductors from the physics viewpoint. Introductory chapters cover the principles of atomic physics and electrical conduction. The author then discusses the practical transistor and its fundamental circuit, and compares it to similar vacuum tube circuit. Related semiconductors such as the double base transistor, the double base diode, and the silicon control rectifier are covered, as are the four-layer diode, the bilateral transistor, solar generator, photo transistor, tunnel diode, etc. (Irving Gottlieb. New York, Rider, 1960. 146p., $3.90.)

PRINCIPLES OF ECONOMICS AND THE CANADIAN ECONOMY.

The aim of this volume is to provide the reader with a description of the principles of economics, and to show their application and operation in the framework of the Canadian economy. The author has divided his subject into eight parts, the first of which provides an introduction and description of the different forms of business organization. Other parts cover: the theory of price and pricing; the business firm and industry; competition and monopoly; the distribution of income, including production, wages, trade unions, in Canada, the U.K. and the U.S., rent, interest and profit; international trade; public finance; money and banking; the national income.

The author provides the historical background for the various Canadian policies and institutions, and compares the Canadian situations with that in the United States. This is a very interesting and useful volume. (R. C. Bellan. Toronto, McGraw-Hill, 1960. 540p., $7.50.)

***METHODS AND TECHNIQUES IN GEOPHYSICS, VOLUME 1.**

A collection of papers dealing with modern physical techniques employed in determining and dealing with physical information about the earth. Contributors from the U.S., Canada, and Britain discuss measurement of temperature gradient in the earth, heat flow over land, geomagnetic elements, gravity at sea, and in palaeomagnetism; earth currents and the detection of earth movements; borehole surveying; properties of rock under high temperature and pressure; and the latitude, longitude, and secular motion of the pole. (Ed. by S. K. Runcorn. New York, Interscience, 1960. 374p., $10.00.)

***TECHNICAL COMMUNICATION.**

Written with the engineering student in mind, this book will also be useful to the practicing engineer and those in some other professions. The first three chapters discuss the qualities of good writing, the organization of material, and the use of exposition. The business letter is covered in detail. There is an extended treatment of reports and information on technical articles, magazine writing, oral communication and the use and preparation of tables and figures. The final section of the book is a manual of general composition, containing a review of the general principles of composition and a glossary of usage. (G. C. Harwell. Galt, Brett-Macmillan, 1960. 332p., $3.75.)

***PROGRESS IN NON-DESTRUCTIVE TESTING, VOLUME 2.**

This is the second volume in a series of annual critical reviews on international progress in non-destructive testing. Papers included cover the uses of radiology with high-energy X-rays, electrical methods, radioisotopes, ultra-sonic waves, and paramagnetic resonance in this type of testing. The theory and practical application of these methods of studying and detecting flaws in metal structures are presented, as well as studies of ageing and precipitation in metals using anelastic damping measurements. The mechanical testing of high polymers is also dealt with. (Ed. by E. G. Stanford. Galt, Brett-Macmillan, 1960. 250p., $12.00.)

°HANDBOOK OF GEOPHYSICS, REV. ED.

Sixty experts collaborated in the preparation of this encyclopedic source of geophysical information, which contains many tables, figures, and references to other publications. Included are papers on model atmospheres and atmospheric pressure, density, composition and electricity; atmospheric exploratory devices and acoustic propagation; temperature, wind, precipitation, clouds, visibility, the sun, meteors and the ionosphere; thermal and cosmic radiation; electromagnetic wave propagation and geomagnetism; terrestrial surface parameters and jet aircraft condensation trails. (U.S. Air Force. Galt, Brett-Macmillan, 1960. Various pagings, $15.00.)

°SYMPOSIUM ON FATIGUE OF AIRCRAFT STRUCTURES.

Presents nine of the twelve papers given at the Symposium. Of the remaining three, two will be published later and one has been withdrawn. Topics covered include the handling of fatigue data in a practical design case, probable loading conditions encountered by aircraft, supersonic fatigue test methods, fatigue behavior under high biaxial stresses, helicopter problems, methods for improving fatigue behaviour, methods for predicting rates of fatigue crack propagation and cumulative damage due to variable-amplitude loading. (Philadelphia, American Society for Testing Materials, 1960. 138p., $4.00. s.t.p. 274.)

°SYMPOSIUM ON SPECTROSCOPY.

This volume contains sixteen papers presented at the Symposium dealing with such topics as atomic, X-ray, infrared, molecular, ultraviolet, magnetic resonance, and electron paramagnetic resonance spectroscopy, flame photometry, infrared and spectroscopic analysis, and applications in geochemistry, petroleum technology and other fields. Also included is a non-symposium paper dealing with application of spectrography to the analysis of water formed deposits. (Philadelphia, American Society for Testing Materials, 1960. 245p., $7.00. s.t.p. 269.)

°PAPERS ON SOIL, 1959 MEETINGS.

This volume includes 29 papers presented at four separate sessions of the 62nd annual meeting and the 3rd Pacific Area meeting, ASTM, during 1959. Strain-rate effects, consolidation of clays and soils, repeated loading measurements, and a literature survey 1846-1958 on dynamic resistance of cohesive soils, are considered in 8 papers from the Symposium on Time Rates of Loading. Nine papers from the Symposium of Atterberg Limits discuss manifold aspects of the various Atterberg Limit tests. Three papers presented at the Session on Soils cover laboratory and field tests on granular materials, application of lime for soil stabilization, and the preconsolidation of a sensitive clay. The remaining nine papers were presented at the Symposium of Soils for Engineering purposes, and cover problems related to soil density, moisture content, load and compression testing and a proposed classification system for soils. (Philadelphia, American Society for Testing Materials, 1960. 375p., $9.00. s.t.p. 254.)

INSTITUTION OF STRUCTURAL ENGINEERS JUBILEE SYMPOSIUM ON HIGH STRENGTH BOLTS, 1959. PROCEEDINGS.

This volume includes the nineteen papers presented at a Symposium on the structural use of high strength bolts, together with the discussion on them. The papers are divided into three sections, the first being concerned with history, research and principles of design of these bolts. The second section covers the properties of bolts, and the tools used to place them. The last set of papers discusses the use of bolts in various types of structure, and in different countries. (London, Institution of Structural Engineers, 1960. 203p., £4.)

Correction

On page 168 of the November Engineering Journal the publisher of *Mobile Manual for Radio Amateurs, 2nd Ed.*, was incorrectly stated. The book was published by The American Radio Relay League, West Hartford, Conn.

(*More Library Notes on page 142*)

If you are an E. I. C. member, you are a member of the Membership Committee.

Stan Cassidy

From letters to the editor . . . .

Erich J. M. Knitel, M.E.I.C., of Montreal, asks: "Can Canada in the long run afford to lose qualified engineers?" He answers his own rhetorical question with "certainly not, but she does; and there are only vague tendencies to avoid such a situation."

Mr. Knitel reviews efforts on both sides of the Iron Curtain to provide engineers and technicians and feels statistics prove the free world is being out-stripped in this sphere.

"'One sole technician is worth more than 10 Communists'," he quotes Lenin as having said, and feels this is a reflection "in the intensive but silent efforts of the Soviet Union."

The Federal Government of West Germany appreciates this situation, Mr. Knitel says, and to help rectify it, the Internal Department recommended: unification in the structure of engineering schools and in the access to engineering schools; adequate salaries for lecturers; establishment of scholarships for engineering schools.

"When we consider the situation in Canada," Mr. Knitel writes, "we must say there is quite a similarity to the . . . problem. In other words, Canada does not produce enough engineers to exploit in an adequate way her natural resources and consequently to offer a solution to the crucial unemployment problem."

"From this, it is quite obvious that Canada can not afford to lose any engineer, not only because she reduces her capacity to settle her own technical problems, but also each engineer leaving Canada reduces the national patrimony of Canada but shows this with a lack of patriotic feeling.

"On the other hand, there are several reasons which encourage the migration of engineers from Canada. At least there is nothing done to prevent such an intolerable situation.

"Essentially, the reasons are: more attractive salaries elsewhere; professional recognition; more interesting and diversified working fields; more freedom in the application of engineering knowledge; greater opportunities of professional advancement.

"These are the facts. The writer knows at least 10 cases where this happened. From his own small circle of personal friends, he, for instance, is the last of six immigrant engineers in electronics who did not go to the United States. The other five went.

"What has Canada done to avoid this? Nothing, with the excuse that we are a democratic country. It is said that nobody can be forced to do something he does not like—and there is the crucial point. It is obvious nobody should be forced to remain, but remaining ought to be made so attractive that everybody would like to stay.

"Thus, it lays in our hands and in the competent authorities to wake up, to do something (other than) talk about it, in order that migration of engineers from Canada would be avoided in a natural way."

● LIBRARY NOTES

(Continued from page 132)

*MANUEL DE POSE DES PIPE-LINES.

A guide for engineers and technicians, this book also demonstrates one aspect of modern developments in construction processes and illustrates the application of assembly-line techniques to this field. An introductory chapter assesses the importance of pipelines in the petroleum industry, describes the features of pipeline projects unique amongst hydraulic projects, and gives a general survey of the elements of pipe-line construction. Succeeding chapters treat in turn each step in construction, such as location, survey, excavation, and final covering of the trench; transport, laying, bending and joining of the pipe; and miscellaneous topics such as special features of the construction camp, and the crossing of existing lines and of bodies of water. (L. Lévêque. Paris, Eyrolles, 1960. 181p., NF 24.35.)

*MATERIALS SELECTION FOR PROCESS PLANTS.

This handbook contains data on the mechanical properties, fabrication characteristics, and corrosion-resisting qualities of metals, plastics, rubbers, paints, and cements for use in process equipment. The emphasis is on the prevention of corrosion, and the various types of corrosion and their prevention are first presented. The author then outlines information on the properties and applications of iron, steels, plastics, rubbers, chemical-resistant cements, paints, and alloys of nickel, copper, aluminum, lead, and titanium, gathered from his own experience, from literature sources, and from manufacturers' catalogs. (R. E. Gackenbach. New York, Reinhold, 1960. 318p., $8.50.)

*THE USES OF ELECTRICITY IN THE OIL INDUSTRY.

A reference book for electrical and power engineers in the petroleum industry, and for manufacturers of electrical equipment for use in the industry, which details the practices adoptel by British oil companies. One chapter also describes where these differ from continental and North American practices. Distributed in America by Professional Books Inc. (Ed. by E. A. Reeves. London, Ernest Benn, 1960. 296p., $10.00.)

*DICTIONARY OF NUCLEAR PHYSICS.

5,000 English-German and German-English terms each, used in uranium mining, reactor building, nuclear fission and fusion, isotope research, and in other fields of nuclear physics. Particular consideration has been given to nuclear physical symbols and abbreviations of which more than 600 are included. (Ed. by H. Rau. New York, W. S. Heinman, 1957. 247p., $5.00.)

*VDI-STEAM TABLES, 5TH ED.

In this new edition the temperature range remains the same but the pressure range has been extended to 500 atm. The three sections of the tables are as follows: state of saturation (temperature table); state of saturation (pressure table); values of volume, enthalpy and entropy for water and super-heated steam. The large folded Mollier diagram is in a pocket at the back. The foreword and the explanatory introduction are given in three languages — German, English and French. (Ed. by E. Schmidt. Berlin, Springer-Verlag, 1960. 119p., 15 DM.)

INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, SIXTH CONGRESS, 1960. PRELIMINARY PUBLICATION.

This preliminary volume, published before the Congress, which was held in June, contains the papers on basic subjects which were to be discussed. Six working sessions were arranged, the first of which dealt with general questions, the basis of structural design, the properties of materials, and the development of methods of calculation. The first of the two sessions on metal structures considered new developments of connections, welding and pre-stressed, high-strength bolts, while the second dealt with the steel skeleton, design and execution, slabs and walls, and safety. Two sessions on reinforced and pre-stressed concrete dealt with developments in bridge building, safety, reinforced structures, connection methods and the redistribution of stresses due to creep. The sixth session was devoted to composite construction and new developments, particularly in the fields of nuclear power, dams and bridges. Altogether 58 papers are included, and five Canadian engineers are among the authors.

A final report will contain the discussion on the papers listed above, as well as additional papers on practical applications and special problems. (Zurich, Leemann, 1960. 928p., 70 Sw. Fr.)

*VIBRATIONS FROM BLASTING ROCK.

The author's purpose is to compile in brief but useful detail the most important factors concerning the nature and effect of vibrations generated by the use of explosives. He discusses explosives and blasting caps, rocks and their rupture by blasting, the elastic-wave pattern of vibrations, and the effects on neighboring structures of explosion energy waves. (L. Don Leet. Toronto, Saunders, 1960. 134p., $5.95.)

*INTRODUCTION TO STRUCTURAL MECHANICS.

For civil engineering students in a first course in structural analysis. The general theory and the applications of that theory to structures such as roof trusses, railway and highway bridges, are treated in separate chapters. General methods rather than techniques of limited application are emphasized. (P. Andersen and Gene M. Nordby. New York, Ronald Press, 1960. 340p., $9.50.)

(More library notes on page 156)

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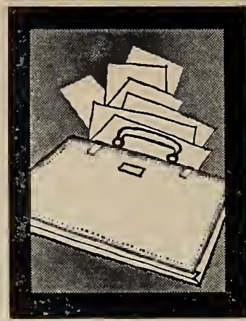
Business and Industrial Briefs



Appointments and Transfers

Canadian Liquid Air Company Ltd. has appointed **James Baillie McClelland** Manager, Technical Development, Ontario Region.

The appointment of **J. Milton Murdock** as Product Manager, Pump Department, has been announced by Montreal Locomotive Works Limited.

W. S. Haggett has been named President of The Bristol Aeroplane Company of Canada Limited and of its subsidiary, Bristol Aero-Industries Limited.

John Inglis Co. Limited, Toronto, has appointed **P. C. Hensman** as Manager, Hydraulic Department.

The promotion of **Allon D. Mack** to Sales Specialist, has been announced by Markel Electric Products, Ltd., Fort Erie, Ont.

Norman K. Anderson has been appointed Vice President, Marketing, by the Canadian Locomotive Company, Limited, Kingston.

The General Sales Division of B.C. Electric and the Industrial Development Department of its affiliated company, Western Development and Power Limited, have been merged. **E. D. Sutcliffe** has been named General Manager of the new division.

Trane Company of Canada, Limited, Toronto, has appointed **Brian E. Judges** as General Sales Manager.

Edmond G. Eberts has been appointed a technical sales representative by Union Carbide Canada Limited in their Chemicals and Plastics Division at Montreal.

Frederick L. McAdam has been appointed chief engineer of Marshall Macklin Limited, Consulting Professional Engineers and town planners, Don Mills, Ont.

John A. Fuller has been appointed Sales Manager of Worthington (Canada) Ltd., Toronto.

J. W. Craig has been appointed Vice President of Canadian Refractories Limited.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A SERIES of special pipe nozzles has been installed in the side of a blast furnace at Hamilton. The nozzles are physical evidence of a joint experiment by Dominion Foundries and Steel Limited, Imperial Oil Limited and Esso Research and Engineering Company to determine whether heavy fuel oils can be burned in blast furnaces. If the experiments are successful it will mean increased efficiency for steel makers at a time when they are facing mounting costs and competition.

THE EFFECTIVENESS and safety of Perlox insulating fill for all cryogenic applications are outlined in a four-page brochure published by Canadian Johns-Manville. Stressed are the reasons why Perlox, completely inorganic, offers maximum safety in all extremely low temperature installations involving oxygen, nitrogen, argon and other gases used in industrial processing.

WELDING METALLURGY is the subject of a pocket-sized booklet published by the American Welding Society. It is a condensed textbook concerning ferrous and nonferrous welding metallurgy prepared and reviewed by some of the finest metallurgists in the United States. It contains 122 pages, 45 illustrations, 25 tables and 25 diagrams.

DIVIDENDS have been declared on two issues of preferred shares of the Shawinigan Water and Power Company. On the series A four per cent cumulative redeemable preferred shares the dividend is 50 cents, and on the series B 4½ cent cumulative redeemable preferred shares it is 56¼ cents.

A TWO-PEN potentiometric round-chart recorder-controller, accurate to within one-quarter per cent has been announced by Canadian General Electric. Engineers at the company's Meter and Instrument Section, Quebec Plant, say the instrument, an adaptation of the G-E single-pen-round-chart model, can be used in nearly any industrial application where two variables must be recorded on a single chart.

CONSOLIDATED EARNINGS of The Shawinigan Water and Power Company, St. Maurice Power Corporation and Southern Canada Power Company Limited amounted to $1.16 per common share for the first nine months of 1960, after deduction of all charges and provisions for preferred and class A common shares. This compares with $1.05 for the nine months ended Sept. 30, 1959.

A METHOD OF PRINTING in which there is no screen formation has produced high quality work in black and white and in full colour in the United Kingdom. The printing company claim that the prints produced are not only exact in tone values, but are of such fine grain that even examination under a magnifying glass shows no loss of detail. For short runs of 500 to 2,000 the process is cheaper than more conventional methods and the cost is not based on per square inch of illustration — as with blockmaking — so that the large illustration is most economical by comparison.

A FULL-SCALE "mock up" of a new 40-million-volt atom smasher at the University of Michigan is demonstrating how to save space and money in building the proposed machine. Built in the University physics laboratory for less than $1,000, the plywood replica already has brought about a saving of $6,000, according to Professor William C. Parkinson who is in charge of the project. The mock-up has shown where a saving of 20 tons of steel could be made in the 340-ton magnet which will encircle the machine's vacuum chamber.

INCREASED LONG-TERM EMPLOYMENT could result from a "joint development of the growing Canadian market for steam turbine generators. The presidents of John Inglis, Co. Limited and of Canadian Westinghouse Company Limited said their firms are co-operating for the production in Canada of such equipment. The feasibility of the arrangement has been enhanced by a ruling of the Department of National Revenue that electric steam turbo generator sets of 700 hp. and greater are of a class and kind made in Canada.

EXPORT COMPANIES have been formed in North America by the Boulton and Paul Group of Companies, the Head Office of which is in Norwich, England. The Group's activities cover constructional engineering, mechanized equipment for steel construction, joinery, wire and wire products, fencing, and builders' equipment. The new companies are: Boulton and Paul of Canada Limited, registered in Toronto; and Boulton and Paul (Nassau) Limited, registered in Nassau.

CANADIAN FAIRBANKS-MORSE has signed an agreement to sell its seven-storey building in Montreal to a real estate syndicate for an undisclosed cash price. President Robert Morse III said the company simultaneously entered into a lease for head office space in the new Canadian Bank of Commerce Building starting in the summer of 1962.

SCLAIR has been registered as the trade name by the plastics division of Du Pont of Canada for the linear polythene resins to be produced at the company's new plant at Corunna, Ont., near Sarnia. The name will identify the resins as Canadian-made and will readily associate them with the St. Clair River Works in Canada's chemical valley, where they are manufactured.

A 32-PAGE BROCHURE, numbered MC211, gives full details of the Mobrey Magnetic Level Switch and Control Range. Installation instructions and wiring diagrams are included in the booklet.

THE LARGEST CONSTRUCTION job in the history of the United States Air Force is described in photographs and text in "Concrete Performance Report" issued by the Master Builders Company. The report gives details of construction of the Air Force Academy complex at Colorado Springs, Colorado. A total of 800,000 cubic yards of ready-mix concrete was designed, controlled and placed under a wide range of conditions during the construction.

HONEYWELL REGULATOR COMPANY recently announced the formation of a new corporate division whose primary objective will be "the advancement of the state of art" of complex integrated control systems for individual and military applications. The move will centralize the company's broad capabilities in developing, installing and servicing specialized control systems such as those needed for complex industrial processes and missile launching installations.

NEW TECHNICAL LITERATURE, containing preliminary data on single crystals of refractory materials, has been issued by Union Carbide Canada Limited, Linde Gases Division. The literature contains a description of the new single crystals, provides data on their physical properties and purity, and describes the size range—diameter and length—in which they may be obtained.

The story behind a brief to the Royal Commission on Publications

Why Canada needs a Canadian business press

Does Canada need a business, professional and technical press of its own? Does this section of the periodical press of Canada contribute to the development and maintenance of the national economic health? Can Canada afford to weaken its independent, Canadian-owned business press?

The business press of Canada is a vital bulwark against further technological and financial dependence upon the United States.

These are the issues behind the brief presented to Canada's Royal Commission on Publications by Business Newspapers Association of Canada. BNA represents some 144 Canadian-owned business, trade, professional, technical and industrial publications, published in English and French. The advertising revenues of BNA member-publications account for two-thirds of the $30 millions in advertising placed annually in Canadian business media.

Among the members of Business Newspapers Association of Canada are the official publications of such respected bodies as the Canadian Manufacturers Association, the Canadian Chamber of Commerce and the Engineering Institute of Canada.

The purpose of the modern business publication might be described as:

1. *To collect and disseminate the experience of those engaged in a certain industry, profession, or trade.*
2. *To act as interpreter of events and developments.*
3. *To serve as a leader of sound thought and policy.*

Canada's business publications play a vital role in Canadian business, professional and industrial life; they are indeed the principal instruments of adult education and training.

The rapid post-war industrialization and development of a complex business community in Canada has made the business executive more conscious than ever of the need for accurate information and sound interpretation.

Business papers in Canada have established themselves as recognized sources of reliable information and ideas—latest inventions, newest developments and technological advances, new production methods, engineering and operating practices, progressive merchandising and retailing techniques, up-to-date economic thinking and policies—without which the Canadian businessman could be operating as he did years ago.

Canadian business publications gather information and attitudes from all corners of Canada and, as a result, many individual business decisions—to buy, to invest, to build or to renovate—are influenced by ideas gained in reading the mature Canadian business press.

It is the function of a good business publication to lead and guide industry thinking; business papers' importance to Canadian business and industry . . . indeed upon Canada's economic health . . . cannot be overstressed.

Here are a few examples of the contribution made by the Canadian business press to business and public life:

¶ A Canadian metalworking publication recently completed a massive census of Canada's metalworking production equipment, a task never before undertaken either by business or government. It revealed that much of this equipment was obsolete, undoubtedly contributing to plant inefficiency.

¶ A Canadian business magazine founded and annually sponsors the Canadian Furniture Mart, which has become the major marketplace for the exhibition and purchase by retail buyers of furniture made in Canada.

¶ A group of Canadian electrical business magazines were responsible for inaugurating the Plantpower Program—an educational activity designed to increase the safety and efficiency of electrical installations in Canada's industrial buildings. This program has since been adopted as a technical service by almost every major Canadian electrical distribution utility.

¶ Another Canadian electrical magazine was responsible for the inauguration of a safe home-wiring program, which has since been adopted by fire departments all over the country, following a series of daily newspaper articles, written by editors of the magazine. In at least one province, changes in legislation for greater public protection resulted from this magazine's activities at the public and industry levels.

¶ A Canadian plumbing and heating journal exposed the public hazards of unqualified installers of natural gas equipment. A series of articles by the magazine's editors, later reprinted in the daily press, resulted in new legislation and stricter control in the public interest.

℄ A Canadian construction magazine last year published a special section on the problems and prospects of winter construction in Canada—a peculiarly Canadian problem. This special section was later reprinted and distributed widely by the Federal Government as part of its program to promote winter construction.

℄ A Canadian packaging magazine was responsible for the foundation of one of Canada's largest trade and technical associations—the Canadian Packaging Association, along with the major Canadian National Packaging Exposition.

℄ A Canadian business publishing company provides a daily reporting service of construction contract awards. Published in a monthly business magazine, these are widely quoted and used in the industry, the daily press and by the Dominion Bureau of Statistics as an authoritative data source.

℄ A business publication serving Canadian retailers in the fashion field realized that, in general, Canadian retailers did not give due recognition to Canadian fashion design. The publication, through a series of articles, impressed this upon the manufacturers and got them to support the establishment of the Canadian Couturier Association, which since has flourished and has, of course, been responsible for the acceptance of Canadian designs which nowadays are shown internationally.

These may seem dramatic and extraordinary examples of the service Canadian business publications render for Canadians. This list can be duplicated one-hundred-fold. Canadian business publications report in detail to Canadians about Canadian professions, technologies and business and provide a platform for Canadian technicians and professional men to address their colleagues on matters of importance.

The national periodical press of any country plays a significant role in the cultural, political, economic and social life of its people. The Canadian business press provides the specialized information needed by Canadians in business and industry.

In Canada, this task takes on a far greater importance because the Canadian people are exposed to such a continuous flood of U.S. opinion and information and Canadian business to continued competition from abroad.

Canada's geographical position, its standard of living, its industrial and commercial development and the language of the majority of its population, leave its business community particularly vulnerable to influence from the U.S.

Business Newspapers Association of Canada believes that a Canada which did not have its own business press would have a much smaller chance of preserving and developing its national identity in the international business world. Yet Canadian business publications are being exposed to very strong competition from foreign publishers on a scale which would seriously threaten the industry's continued existence.

Canadian business paper publishers feel that it is vital that Canada not only retain but develop and strengthen her national identity. Obviously, U.S. publications are edited for U.S. audiences, reflect U.S. philosophies and sell the U.S. business way of life.

The overflow circulation of foreign publications into this country—in the case of U.S. business publications alone over one million copies a year—must have a tremendous influence on Canadians—particularly on our younger business people. The total effect of these publications on the economic and cultural life of Canada is that they, through their editorial and advertising pages, make Canadians most aware of "the American business way of life;" we are in grave danger of becoming pale shadows of U.S. citizens.

For these reasons, we believe, the preservation of a truly Canadian business press is vital to support and foster our national identity as Canadians.

U.S. business publications do not merely overflow into Canada; they compete aggressively for the advertising which is almost the only source of revenue for the Canadian business press. There is increasing competition from U.S. business publishers who offer to Canadians so-called "Canada editions"—a version of the parent magazine with little or no Canadian editorial content and wholly Canadian advertising—or "split-runs," in which the U.S. publisher sells his Canadian circulation separately to advertisers interested in Canada without Canadian editorial content.

If Canadian business publications were to be weakened by "Canada editions" or split-runs of U.S. business publications, the Canadian manufacturer would be at a serious marketing disadvantage vis-a-vis his U.S. or foreign counterpart, who would purchase advertising in these "Canadian" publications at a fraction of the cost of wholly Canadian media.

Canadian business and industry as a whole thus has a vital stake in the preservation of a truly Canadian business press.

Not only is the Canadian business press a vital medium of technical communication which helps keep Canadian industry efficient; it is an important marketing tool for reaching Canadian business buyers with advertising messages from manufacturers and suppliers.

Without a Canadian business press, the competitive pressures on Canadian business could only increase.

Many Canadian industries are subject to extraordinary foreign competition. The Canadian business publishing industry is not alone in this. But because of its peculiar importance to Canada, the position of the Canadian business press, we believe, deserves the attention of Government and industry.

We submit that Canada's business press is a priceless national economic asset which we dare not leave at the mercy of extraordinary competition from abroad.

BUSINESS NEWSPAPERS ASSOCIATION OF CANADA

An organization of 144 *Canadian* business, professional and technical publications

100 UNIVERSITY AVENUE, TORONTO, ONTARIO

Beaver Bill Says —

Mr. John Miner,
Somewhere-in-the-North
Canada

It was a pleasure to hear from you the other day and learn of your current activities.

I was impressed with your observation that you were enjoying work in your new field of responsibility but rather disheartened with the intellectual isolation, in the engineering sphere, so characteristic of small communities like Somewhere-in-the-North.

You'll be interested, I'm sure, to learn there is no valid reason why you and your nine or ten engineer neighbours cannot attend the Annual Meetings and Regional Conferences of your own EIC, or major meetings of either the Institutions of Civil, Mechanical, and Electrical Engineers in Great Britain, or the Founder Societies in the U.S.A., and do this without moving away from Somewhere-in-the-North or spending more than some ten dollars a year between you. How? It's very simple, John.

Your EIC has reciprocal arrangements with the Institutions and Societies whereby EIC members can secure their publications at member rates. The rest is up to you.

However, I suggest, John, there's a very easy way of actually participating. The Manager of Technical Services, EIC Headquarters, will be glad to help, on behalf of the Committee on Technical Operations and its 10 Engineering Divisions, by sending you a few preprints of our own meetings and of any of the other Societies mentioned, once you stipulate your field of interest. Distribute the extra copies to your engineer colleagues. Encourage one of you—say Cam Mechanical (He is very good at this, I recall)—to study one of these preprint papers. Get together at one of your homes or other convenient meeting place. Get Cam to make a brief presentation of the significant aspects of the paper and a few suggested points for discussion. Everyone of you can discuss it. Have someone, perhaps Al Electrical, record the principal points where clarification would be helpful. Send these comments in to the Manager of Technical Services. He'll pass them along to the author. I'm sure most authors will oblige by answering. The Manager of Technical Services will forward the author's comments to you.

It's easy, John. Try it out. I suggest you and your confreres can have a lot of mental stimulation by forming such a discussion group. It's not only good for mental stimulation but it's professionally broadening. Moreover, one of these days, you'll find there's enough interest Somewhere-in-the-North to warrant founding a Branch of the EIC.

Yours sincerely,

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Beaver Bill Says —

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Maybe it will be selected for an Annual Meeting or Regional Conference. Maybe it will be published in the Journal or Transactions. It's up to you!

● LIBRARY NOTES

(Continued from page 142)

°SYMPOSIUM ON NEWER METALS.

The three sections of this text correspond to the three sessions of the Symposium. Section 1, "properties of refractory metals", includes papers on high-temperature testing methods and properties of molybdenum, tantalum, columbium, and the platinum group metals. Section 2, "Nuclear and light metals", includes papers on beryllium, zirconium, and yttrium. Section 3, "Processing of newer metals", is concerned with purification and fabrication of columbium, tantalum, molybdenum, chromium and lithium. An additional paper is included in this volume to supplement the information on zircaloy alloys, dealing with the application, to the analysis of zircaloy, of coulometric determination of tin. (Philadelphia, American Society for Testing Materials, 1960. 218p., $7.25. s.t.p. 272.)

°SYMPOSIUM ON DURABILITY AND WEATHERING OF STRUCTURAL SANDWICH CONSTRUCTION.

The seven papers presented at the Symposium deal with: the effect of normal aging on strength of glass-fiber reinforced-plastic honeycomb cores; effect of natural environment on sandwich structure with AMS 3722 paper honeycomb-cores; effect of environmental exposure on adhesive-bonded structures; experience with sandwich construction in aircraft applications; temperature rise in structures due to solar heating; effect of climatic variations on polystyrene foam-core sandwich panels in roofs and walls; and experiences with structural sandwich in building construction. (Philadelphia, American Society for Testing Materials, 1960. 71p., $3.00. s.t.p. 270.)

°NOISE REDUCTION.

This volume was developed from lectures given by various authorities at four special summer programs from 1953-1960 conducted by MIT on the subject of noise reduction in industry. The introduction takes the form of a literature survey and bibliography on the historical background. Intended to be readable by graduate engineers in nearly any technical field, the material is organized in four sections — sound waves and their measurement; fundamentals underlying noise control; criteria for noise and vibration control; practical noise control. (Ed. by L. L. Beranek. Toronto, McGraw-Hill, 1960. 752p., $16.75.)

°CALCUL RAPIDE DES POUTRES CONTINUES PAR LA METHODE DE M. CAQUOT.

"Caquot's method" for the rapid calculation of continuous prestressed-concrete beams has been adopted by the French government as a standard method, as being the best, simplest, and most rigorous amongst the many attempts at simplification of these complex calculations. In this book introductory pages explain the need for a method or rapid calculation and describe the Caquot method. In the following first and second major sections, the authors extend the method to apply for all systems and types of loads, first in theoretical and then in practical applications. Section three contains formulae for various load and beam systems. (Marcel and André Reimbert. Paris, Eyrolles, 1960. 260p., NF. 35.45.)

°STAHLBETON TABELLEN.

Tables for the calculation of reinforced concrete structural elements of rectangular or T-shaped cross-section. The basic formulas are given and the method used in deriving the tabular values. These tables replace the previously published tables by Max Ritter. (K. Hofacker. Zurich, Verlag Leemann, 1959. 64p., 15 Sw.Fr.)

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